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PERISTALSIS IN HEALTH AND DISEASE*†

FIRST CALDWELL LECTURE

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SAN FRANCISCO, CALIFORNIA

MR. PRESIDENT, Members of THE AMERICAN ROENTGEN RAY SOCIETY: I wish first to thank you for the great honor you have done me in asking me to give the first Caldwell Lecture. It is a pleasure to join with you in remembering the name of one of the martyrs of medicine—a man who gave his life for the advancement of science. He was a pioneer, an inventor, a research worker, a versatile, enthusiastic and lovable man; and we are all losers by his death. We shall honor him best by carrying on the work which he loved so much, and which meant everything in life to him. I believe we shall carry it on most rapidly when we do as he did, when we venture out into "pure" science —into physics, chemistry and engineering, to improve our apparatus; and into biology, physiology and bio-chemistry to explain our findings in the body. How much more rapidly our transformers and tubes would have been improved if there had been more men like Caldwell at work in the field; and how glad we should be to-day that some manufacturers have at last seen the incalculable benefits that can come through proper co-operation with a physicist like Dr. Coolidge!

Every advance in technique brings its problems of interpretation. I shall never forget my delight when, in 1912, I got my first radioscope from Vienna and saw the peristaltic waves coursing over the stomach. At first it seemed as if all my desires had been fulfilled, but in a few months this feeling of satisfaction gave way to one of worry over the many things which I saw but could not interpret. I went East and told my troubles to Cannon, who frankly admitted that many of our pathologic findings are not explainable on the basis of the myenteric reflex or the acid control of the pylorus. He gave me room in the laboratory and told me to go to work on these problems myself. He showed me how to open an (anesthetized) animal's abdomen under salt solution so that I could watch the peristaltic movements. Two or three days of this and I saw that the problems I had set for myself were too big and too complicated. I was like a man who would repair a wireless telephone without first knowing the structure and inner workings of the constituent batteries, induction coils, condensers and magnets. It was clear that I had to begin back near the beginning, on prob-

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† This lecture will be published complete in book form by the publisher of THE AMERICAN JOURNAL OF ROENTGENOLOGY.

lems which to an onlooker might appear to have no promise of practical value. The intestine is a tube made up of smooth muscle and it seemed to me that if I could learn more about the properties and peculiarities of that tissue I would come near to solving some of the riddles of peristalsis. Hence it is that for the last seven years I have turned somewhat aside from the clinical journals and have delved into the literature of the experimental zoologists, the physiologists and the comparative anatomists. I have studied smooth muscle in organs other than the bowel—in the bladder, the ureter, the vas deferens, the uterus, the arteries and the iris. Many helpful suggestions have been gotten from studies on snails, sea-cucumbers, anemones, jelly fishes, clams, worms and crayfishes. I have found the medical indexes almost useless in this work, because the most helpful articles are often concealed behind the most uninviting titles. Thus, who would have expected to find an explanation for the gastric upsets of fevers and asthenic states in an article on the swimming plates of a tiny water organism?—yet there I believe it is. The author is Professor Child, a zoologist, and the article is entitled, "The Gradient in Susceptibility to Cyanides in the Meridional Conducting Path of the Ctenophore Mnemiopsis." [1]

It is unfortunate that we practicing physicians must often miss the most thought-stimulating articles because they are buried away in the highly technical journals which we do not ordinarily read. Some day we may have a better abstracting service, but in the meantime we shall probably have to do occasionally as the Israelites did when they approached the Promised Land; we shall have to send out spies to look over this field which we ourselves have so little time to explore, and to bring back some of the fruits. When asked to speak before you to-day, it seemed to me that the best service I could render would be to bring to you some of the ideas which I, a practicing physician and radiographer, have gotten during my sojourn among the physiologists.

THE AUTONOMY OF MANY PARTS OF THE BODY

The first of these ideas is that *the forces which bring about, modify and control peristalsis must be looked for mainly within the walls of the gut itself.* I cannot too strongly emphasize this point, because it seems to me that the failure to grasp it is the greatest stumbling block to further advance in the knowledge of our subject. Whenever I describe some of the regional differences in behavior which can easily be demonstrated in the excised stomach and bowel, someone is almost sure to say: "Oh, that is due simply to the autonomic and the sympathetic." Another settles the whole problem by calling it a "Reflex." When I point out that the peculiarities persist in little pieces of muscle which have been cut out and kept in the ice box for several days, these individuals still ascribe everything to the activities of the canny little ganglion cells in Auerbach's plexus.

Now, the most paralyzing thing in scientific work is a facile explanation which puts a stop to further curiosity without really advancing our knowledge of the subject; and I have never been able to see the value of pushing the explanation for a mechanical phenomenon out of the organ in which it might be studied, and into a tiny ganglion where we can hardly follow it. It seems to me that many even of the teachers of physiology have a wrong idea of the nervous system and its relation to the viscera. They look at it somewhat as an electrical power house which not only supplies the motive force but controls the activities of the various trains running over a railroad. My analysis of the literature makes me feel that we should look at it more as a telephone switchboard with wires which carry nothing but messages of warning and advice from one engineer to another. The trains supply their own power; and the differences in speed and other activities are due to peculiarities in fuel, differences in the gradient of the road, etc.

Anyone who will study the behavior of the lower forms of life before and after removal of their nervous systems will see that the nerves are there primarily to expedite conduction. The ganglionic cells are nutritional centers and not storehouses of wisdom and power. Some of the most complicated "reflexes" are performed by decerebrate animals or by excised parts of these animals. Loeb, Parker and others have shown clearly that the mechanisms are local and comparatively simple.

THE MYOGENIC NATURE OF THE RHYTHMIC CONTRACTIONS

Similarly, in the gastro-intestinal tract we find that after the preliminary shock has worn off, digestion goes on quite normally after complete section of the vagi and the splanchnics. We get good peristalsis in the stomach and intestine that have been removed from the body and either perfused or placed in oxygenated Locke's solution. We get active peristalsis in small segments of gut and in pieces of muscle stripped from the wall. It is clear then that the gastro-intestinal tract is autonomous: it carries within itself all the mechanisms essential to peristalsis.

The next question is, what part is played by the muscle and what part by Auerbach's plexus? Practically all writers on the subject state that the rhythmic contractions are due to stimuli coming from the ganglion cells of the plexus. They base this opinion on the first few papers by Magnus, who found that strips of circular muscle from which the plexus had been removed did not contract rhythmically. Unfortunately no one seems to have noticed that in his fifth paper,[2] Magnus admits that these same plexus-free strips did beat when he added a little physostigmin, strophanthin or barium to the solution. Moreover, no one notices the work of Gunn and Underhill [3] who repeated these experiments, and by taking greater precautions to avoid trauma, obtained plexus-free strips which would contract rhythmically without the help of tonic drugs. This is what we should expect, because it has been well proven in many ways that rhythmic contraction is a function of muscle itself.

It is clear then that the man who would understand peristalsis and the various activities of the stomach and bowel must pay particular attention to the properties and reactions of the gastro-intestinal muscle. Some may ask: what then is Auerbach's plexus good for? It almost undoubtedly serves for the conduction of stimuli and the coordination of movements; it enables the muscle to respond properly to stimuli coming from the underlying mucous membrane, and it helps in some way to keep that muscle from contracting down into a hard knot. Such contractions are well known to biologists, and somewhat resemble the spastic paralyses of striated muscles.

THE AUTONOMIC AND THE SYMPATHETIC

The next question is: what is the significance of the vagus and sympathetic nerves running to the intestine? The average clinical writer to-day states that the autonomic (vagi and sacral nerves) stimulate, and the sympathetic fibers inhibit the intestine. Disease is supposed to follow an unbalance between these two effects. This unbalance can be diagnosed and corrected by the use of certain drugs which are supposed to be elective in their actions. These theories of vagotonia and sympathicotonia have had a strange fascination for the medical mind; they have been dragged in with the utmost assurance to explain all sorts of disease states; and I believe have had a most unfortunate influence on our conceptions of gastro-intestinal physiology. It may be that these theories will eventually prove useful; but in my opinion their foundations are so shaky that some day the whole edifice is going to go. In the following brief discussion I can only point out a few places in which the proponents of these theories have made things much simpler than they really are.

Although in the main, the vagus tends to stimulate and the sympathetic to inhibit the stomach and bowel, these effects are generally transient, often indecisive and not infrequently reversed. They vary with the strength of the stimulus and with the condition of the muscle. The next objection is that the whole theory of "nerve endings" and "intermediate substances" is shaky. Leading pharmacologists have for some time been calling attention to the many contradictions in the literature of the subject, and have warned us to be careful in accepting physiologic conclusions based upon the supposed activities of the various nerve poisons.[4]

Perhaps the strongest objection to the recently revived theories in regard to the autonomic and sympathetic systems is that they make it appear that the sympathetic nerves with the celiac ganglia constitute a separate and distinct brain system which can be antagonistic to, or out of harmony with the central nervous system. This view is entirely at variance with the facts, which have been collected and discussed in a masterly way by Gaskell in his monograph on "The Involuntary Nervous System."[5] He shows that the involuntary nerves and ganglia are a part of the central nervous system; they are connected with it just as the voluntary nerves are, and they have developed from the same embryonic cells. The main difference is simply that the motor ganglia which in the voluntary system are found in the anterior horns of the cord, have migrated, some as far as the paravertebral ganglionic chain; some into the solar plexus, and some into the nerve nets in the walls of the hollow organs. Hence it is that the rami communicantes or preganglionic fibers in the sympathetic system, and most of the efferent fibers in the vagus are simply elongated connector neurones such as we find between the motor and sensory roots in the cord, and in the pyramidal tracts. Furthermore, it has been shown that there are no commissural fibers between the different sets of sympathetic ganglia such as would have to be present if these ganglia were to mediate reflexes like an abdominal brain.

VALUE OF THE EXTRINSIC NERVES

We learn then from Gaskell the same lesson that we have had from Loeb and from Parker: that the nerves are there to conduct, and not to exercise faculties requiring almost human intelligence. There are times when the animal as a whole needs to communicate with its digestive tract; there are times also when the tract must communicate with the body. There are many times when one end of the tract must communicate with the other; and on all these occasions the extrinsic nerves come into play. The vagi carry feelings of hunger and of satiety from the stomach to the brain; they help in adjusting the tone of the stomach wall to the food coming down the esophagus; and they carry the stimuli that give rise to the psychic secretion of gastric juice. If the food must be rejected by vomiting they carry the impulses which bring the abdominal muscles to the aid of the stomach. They probably carry messages from the digesting tract which make the animal feel comfortable and sleepy. The splanchnics serve largely to quiet the tract and to stop digestion when the body is distressed or injured. The extrinsic nerves probably have much to do with the digestive upsets with disease elsewhere in the body; but we shall see later that these changes can be accounted for also by actual damage to the gastro-intestinal muscle.[6]

I regret that I have had to spend so much time on this subject of nervous control; but it seems that the human mind is not so ready to look for new explanations for well-known phenomena, or even to accept them when found, until its contentment with the old explanations has been disturbed. Now that we see how autonomous the tract is and how dangerous it is to rely on theories of ganglionic control, we should be the more eager to learn all we can about the gastro-intestinal muscle.

SMOOTH MUSCLE

As you know, smooth muscle is made up of spindle-shaped cells which vary in size, shape, number of nuclei, etc., in different animals and in different parts of the same animal. As a rule it contracts more sluggishly than striated muscle does; it takes longer to get started, and it is slower in recovering its original length. After a number of strong stimuli or sometimes after only one, it may become quite refractory. After a long rest it may seem to get on a hair trigger again so that it responds powerfully and explosively to a slight stimulus. That is the condition of the digestive tract after the night's rest; and it probably has much to do with the fact that most of us have the daily bowel movement in the morning, immediately after breakfast. With an animal open under salt solution, one can often start a rush wave down the bowel by pinching the duodenum. For some time afterwards, similar pinches will have no effect, but if we wait long enough we will again find the bowel so sensitive that the slightest stimulus will start a wave.

Another characteristic of smooth muscle is its ability to maintain a firm and lasting contraction without fatigue. We see this in the muscles which close the shells of bivalves and we see it in the wall of the colon. It is interesting that the muscle in a bivalve consists of two parts: one which closes the shell and the other which locks it closed. By cutting first one and then the other it can be shown that neither one can do the work of the other. Similarly, if one of you will try to hold his arm out perpendicularly to his body he will soon find it a most painful and fatiguing experiment. The deltoid was not designed for such heavy work, but the glutei and back muscles are carrying much heavier loads all day, and they do not complain. There are all kinds of muscles, all suited to different purposes. Some, like those in the wings of insects, must contract 300 times a second; others like those in the wings of a hen have little to do. Those who think all muscle is the same forget the diffenences between the white and dark meats of chicken, between the heart and the gizzard; between the tenderloin, roundsteak and tongue. I have gone into these differences so at length to prepare you for the thought that there are big differences between the muscle in the cardiac and pyloric ends of the stomach;[7] between that in the small intestine and that in the cecum [8] and colon.[9] The muscle on the lesser curvature near the cardia is soft to the touch like coagulated fibrin; that in the pyloric antrum is tough like gizzard and has a different color. Stimulate the two with an electric current or with a pinch and you get two entirely different contraction curves; put them into warm oxygenated Locke's solution and you get two different types of rhythmic activity. These differences were to be expected when we remember that the upper and lower ends of the stomach have different kinds of work to do. The upper end serves largely as a hopper to hold the food; the lower is the mill that does the heavy work. More of these local peculiarities will be described later.

Another characteristic of smooth muscle in hollow organs is its responsiveness to tension. Most of the manifestations of peristalsis are brought about and regulated largely by the internal pressure due to the presence of food or gas. Cannon has shown that the rhythmic segmentation in the small intestine is due simply to the fact that those muscle fibers which are stretched tend to contract.

Smooth muscle shortens also under the influence of direct irritation. Thus we find contraction of the cardia, pylorus, ileo-cecal sphincter and anus when there is ulceration or inflammation near by. We find hour-glass contractions of the stomach opposite ulcers on the lesser curvature; and shrunken and irritable duodenal caps with ulcers in that region.

PERISTALSIS

If we stimulate the smooth muscle in a tubular organ like the intestine or ureter, we

get a contraction which produces a tonic ring. From this ring, waves are given off in both directions. They remind one of the ripples which arise at a point where a stone has been thrown into a pond. The impulse spreads from muscle fiber to muscle fiber, and need not be mediated by nerves, ganglia, centers or reflexes. I have observed, after electrical stimulation, similar waves spreading both ways along the segments of a recently voided tapeworm; and I have seen them traveling away from the ridge which forms when one strikes the irritable pectoral muscles of a consumptive. It seems to me that the stimulus probably increases the chemical activity at the point where the tonus ring forms; it raises the metabolic rate, and stimuli spread out on both sides down gradients of chemical activity.

GRADIENTS

Returning to the simile of waves spreading in water, it seems to me that some tubular organs may be likened to ponds which are level to begin with; others are more like rivers which have definitely established gradients. In the first case the waves spread equally well in all directions; in the second, the waves spread better down stream than up. Perhaps I can illustrate my point best by showing the evolution of the fixed gradient in the heart. As you know, in that organ the beat follows a gradient of rhythmicity from the sinus to the ventricle. It was Gaskell who showed that if we cut a heart into three or four pieces the one containing the mouths of the great veins will show the greatest tendency to beat rhythmically, and will have the fastest rate. The ventricle will be slow to start beating and will have a slow rate. Now, when we turn to the primitive heart of the sea slug (aplysia), we find a tube which apparently has no constant gradient in either direction. Its beat arises now on one side and now on the other, depending on where the blood produces the greatest tension. Hunter could find no sign of a gradient in the heart of one of the ascidians. In these animals the beat runs for a while towards the viscera and then for a while towards the gills. The pace-making end seems to get fatigued; its rate is slowed and finally the other end is able to assume the pace for awhile. A constant direction of contraction may be maintained by electrical stimulation of either end of such a heart. It seems to me that Hecht's [10] studies on ascidia atra show us the very beginning of the fixed gradient which we find in the hearts of the higher animals. He found that although the heart of the ascidian reverses its beat from time to time, the sum of the advisceral beats is about twice that of the abvisceral. Moreover, as we should expect if the gradient is a little better in the advisceral direction, the rate of conduction is definitely faster in that direction than in the other. If a wave is started in the middle of the heart going both ways it tends to efface the abvisceral waves which according to our theory would have the smaller momentum. It is interesting also that under slightly adverse conditions, as after warming the water or after diluting or concentrating it, it is the abvisceral beat which is suppressed. We find a little more stable, but still reversible heartbeat in the sharks and rays. In them the slightest stimulus to the bulbus aortae will reverse the beat and the same stimulus to the sinus will restore it. Even in the higher vertebrates the heartbeat can be reversed temporarily by agencies which lower the rhythmicity of the auricle or raise that of the ventricle.

There is considerable evidence now that peristalsis in the ureter follows a gradient of rhythmicity from the kidney to the bladder,[11] and I have been collecting data which suggest that there are similar gradients in the vas deferens and the fallopian tubes. We may perhaps be able later to state it as a law that the direction of transport of material in a tubular organ depends on gradients of rhythmicity, tone, irritability and metabolism. When we come to think of it, our experience with engineering and mechanics should have led us long ago to look for gradients in these muscular tubes. We know that

water in a pipe follows gradients of gravity or of pumping pressure; electricity flows along gradients of voltage, the winds follow gradients of barometric pressure, etc.

GRADIENT IN THE INTESTINE

Now what evidence have we that there is a gradient in the gastro-intestinal tract? As far as rhythmicity goes the evidence is overwhelming. It is a simple thing to open an animal (rabbit) under salt solution and to demonstrate that the rate of rhythmic contraction varies from about 20 per minute in the duodenum to 10 per minute in the lower ileum. It is easy also to cut out short segments of the bowel and to show that their rate of rhythmic contraction continues to vary inversely as the distance from the pylorus. A similar gradient can be shown in strips of muscle excised from the wall of the stomach. The fastest rate is found in the strip from the lesser curvature near the cardia. It is harder to show the gradient in the colon, but that was to be expected. Remember that the large bowel is more sluggish than the small; it lets the contents lie in one place for long periods of time and waves can go in either direction over the cecum and ascending colon. Hence it is that the excised muscle is slow to start beating, its rate is slow; it tends to contract down into a hard knot and stay that way; and the gradient is poor and often reversed. In the small intestine of the rabbit and white rat the rhythmic gradient is so fixed, and so intimately "built into" the structure of the intestine that one can determine the oral and aboral ends of short excised segments by counting the rates at the two ends. It has been shown also that when sections of small intestine are cut, turned end for end and anastomosed again, they will transport liquids but not solids, because the original direction of peristalsis is maintained as long as the animal lives. This experiment shows that the gradient is basic and not the result of functional adaptation. Further evidence for that conclusion is found in the fact that it is just as marked in the fetal intestine, which has not yet functioned, as in the adult animal. The permanence of the gradient in the gut is to be expected from studies on the lower forms of life. The mouth of a frog is lined by epithelium covered with little cilia which wave in one direction. If a piece of this epithelium is cut out, turned through an angle of 180°, and grafted back again, the cilia continue to beat in their original direction, now contrary to that in the rest of the mouth. In some of the worms the so-called "polarization" is so perfect that if the animal is cut into a half-dozen pieces they will all crawl in the same direction towards the point where the head used to be.

Before leaving the topic of rhythmic contraction I must make it clear that in the intestine the rhythm of one segment rarely influences the rhythm of the adjacent ones. As you know, in the heart the region with the fastest rate sets the pace for all others, and the wave of excitation travels so rapidly that to the naked eye the mammalian heart appears to contract simultaneously all over. In the stomach, the area with the most rapid rate at the cardia sets the pace, and we can see the waves traveling slowly to the pylorus. In the small intestine each segment contracts at its own rate and only occasionally do we see what are called peristaltic rushes running any distance down the bowel. Although the duodenal muscle has the fastest rate it does not set the pace for the rest of the gut. I must emphasize this point because some writers in overlooking it, have theorized unwarrantably on the basis of some purely anatomical observations reported by Keith.

UNDERLYING BASIS OF THE RHYTHMIC GRADIENT

The next question is: how are these differences in rate brought about? What are they due to? What are the structural differences behind them? As we have seen that these rhythmic movements are myogenic in origin, it is plain that we must look for the differences in the muscle. Now, it has been

shown that the rate of rhythmic contraction is probably dependent upon the rate at which the chemical processes go on. Some substance is built up to a certain point and then exploded to produce the contraction. If the metabolism is slow it should take longer to complete the cycle. We know also that warming hastens chemical processes, and Taylor and I have shown that warming the intestine hastens the rate of rhythmic contraction. As we can take a piece of ileum beating 10 times a minute, and by warming it speed up its metabolism so that it will beat 17 times per minute, it seems to me that the duodenum which normally beats 17 times per minute must have a faster metabolic rate than the ileum. Such differences in metabolic rate have been demonstrated in other organs of the body, where they appear to have great significance.[12] During the last few years Miss Starkweather and I have brought forward a good deal of evidence to show that there is a gradient of oxidation from the cardia to the pylorus, from the duodenum to the ileum and from the ileocecal sphincter to the anus.[13] For the unit of weight and time the muscle from the duodenum gives off more CO_2 than does the muscle from the ileum. This is true not only for the active but also for the resting muscle. Graded differences have been found, moreover, in the catalase content of equal weights of minced muscle. This catalase, which liberates oxygen from hydrogen peroxid, is supposed by some to be an index of the rate of metabolism; and certainly in the bowel the gradients of CO_2 production and catalase activity run very close together. Be that as it may, the interesting thing to me is that we can show a definite chemical difference between the muscle in the duodenum and that in the ileum.[1]

We know that there is some gradation also in the irritability of the intestine as regards distension. The duodenum and jejunum are very responsive to the presence of food or balloons, while the lower ileum and colon are quite tolerant of them. You all know that the barium meal in the jejunum appears in small flecks as if it had been sprayed over the folds of the mucous membrane. In the ileum it forms dense sausage-shaped masses. That is due simply to the greater irritability and activity of the upper bowel.

Hess showed years ago that the pull exerted by the jejunum of a dog on a small balloon is 228 gm., while in the ileum it is 75 gm. Naturally, the food is going to move from the active and irritable regions to the more sluggish and insensitive ones. I cannot conceive of a simpler theory of peristalsis, or one more in harmony with the laws of physics and mechanics.

DIFFERENCES IN PERISTALSIS IN DIFFERENT PARTS OF THE GUT

Let us follow for a few moments the progress of a barium meal through the digestive tract, noting how the peristaltic movements are influenced by local differences in structure and musculature. The mouthful shoots through the first part of the esophagus because the muscle is quick-acting and striated. In the lower third the muscle is largely of the smooth variety and progress slows up. In the stomach the waves begin probably in the pacemaking region near the cardia and travel as shallow ripples until either proper pressure conditions or the presence of the peculiar antral muscle causes them to break into deep waves. If the tone of the stomach is too high the waves may be very shallow or hard to see; if the tone is poor, we may see the best waves at the beginning of the examination when there is only a little food present and the muscle fibers are not too badly stretched.

The waves do not cross the pylorus, probably because of the connective tissue barrier there, the peculiar arrangement of the muscle fibers, and the sudden transition to a different type of muscle. The control of the pylorus is partly chemical and partly mechanical. Cannon has shown that the presence of acid above tends to relax the sphincter and acid below tends to close it. We know

however that this mechanism will not explain the vagaries of pyloric action in achylia gastrica, in duodenal ulcer, carcinoma, etc. We know also that the mere presence of food or of a distending balloon in the duodenum and jejunum will tend to stop the progress of food through the pylorus.[14] It is this mechanism that keeps the stomach from emptying too rapidly after pylorectomies, Mayo-Polya operations and gastro-enterostomies. This holding back above an active or distended part of the gut is easily explained on the basis of changes in the gradient. The digesting, stretched bowel has a faster metabolic rate and a more rapid rate of rhythmic contraction; hence the gradient is likely to be uphill towards it. This will tend to slow the progress of more food coming down from above.[15]

The duodenal cap remains filled and shows almost no peristalsis, probably because the muscle removed from that region shows very little rhythmicity. There is some evidence that the muscle fibers are arranged in festoons and not circularly and longitudinally, as they are elsewhere. This might also tend to modify the contractions. I think the peculiarities of the upper duodenal regions, together with a number of its pathological tendencies, can be traced back to the great specialization and complexity of this part of the bowel in some of the fishes.

As I have already stated, the jejunum is jejune or empty because of its great irritability and rapid peristaltic rate. The food slows up in the terminal ileum because the muscle is more sluggish and because the gradient is uphill for a short distance to the ileocecal sphincter.

In the first third of the colon the gradient is poor, so that the waves can go in either direction. In the rat they tend to be antiperistaltic when the feces are liquid and peristaltic when the feces become drier. The colonic contents move slowly because the muscle is more sluggish and perhaps because the gradient is poor. The tendency for the feces to stay out of the rectum can be explained if I am right in thinking that the gradient is uphill in that region. There is some evidence from animal experimentation in favor of that assumption.[16]

PRACTICAL VALUE OF THE GRADIENT THEORY

This idea of a gradient underlying peristalsis gives us facile explanations for many of the phenomena observed in disease. The gradient of forces can be steepened, flattened or reversed. A duodenal ulcer which raises the irritability and tone of the upper end of the tract often hurries the progress of food through the small intestine; a lesion in the appendix or cecum which raises the irritability of the lower end of the bowel slows the current and produces ileal stasis. A fissure in the rectum may cause back pressure into the cecum with constipation. A patch of enteritis in the jejunum can reverse the current above, in the duodenum and stomach—with vomiting; and can hurry it below—with diarrhoea. A stimulus reaching the jejunum from the brain by way of the vagi—as in sea-sickness—may also empty the tract both ways. The distension of any part of the tract by food raises the tone and irritability of that region and tends to hold back the material coming down from above.

Theoretically, the gradient can be reversed not only by raising the lower end, but by depressing the upper end. My observations on excised segments of intestine from distempered dogs and snuffling cats agree closely with those of Child on the lower forms of life in showing that the most sensitive regions, which have the fastest metabolic rates and the greatest need for oxygen, are injured most by asphyxia, by many drugs and by disease toxins. I have shown repeatedly that a poison can be administered in such dosage as to have no effect on the colon and ileum, while it paralyzes the duodenum and weakens the jejunum. Furthermore, exised segments of duodenum from a sickly rabbit may not contract at all in Locke's solution when similar segments from the ileum of that animal show no sign of toxic influence. A reversal or a flattening

of the chemical gradients can also be shown in many of the sick animals. We have here, then, an easy and very simple explanation for the digestive upsets with intestinal stasis which we see in fevers and asthenic states.

As I have discussed the practical aspects of my theory in previous papers [17] I will not go into the subject any further at this time. Remember, when confronted by an abnormality in intestinal peristalsis, that if the lesion is sufficiently irritating it will raise the local tone; this will reverse the gradient leading to the lesion on the orad side and it will steepen the gradient on the caudad side. Hence it is that it may slow, stop or reverse the progress of material coming toward it from above, and may hasten the progress of material that has passed it. Exceptions to this rule will be found around the stomach where there are many complicating factors not sufficiently understood at present.

In closing, I must admit that with all the work that has been done we still know too little about the origin of many of the disturbances of function which we see in our patients—the hypo- and hypermotilities, the sphincter spasms and the peculiarities in gastric peristalsis. We must keep in mind that we are using a physiologic method, borrowed from Cannon; we must think more in terms of deranged physiology, and must not rest too satisfied with the demonstration of beautiful morphologic defects—ulcer craters, carcinomas, adhesions and displacements. A number of you—practising radiographers—have made excellent physiologic studies on man; studies that are as much pure physiology as those of Cannon and Carlson. Much remains to be done; and if my little message from the biologists to-day should contribute anything to your zeal and skill in attacking these problems I shall be happy.

SUMMARY

We often fail in trying to solve our practical problems because we do not begin near enough to the beginning. We must know more about general principles and the workings of small parts of the digestive tube.

We must venture out more into "pure" science. We can get much help and inspiration from the experimental zoologists and the physiologists.

The digestive tract is largely autonomous, and the forces underlying peristalsis must be looked for mainly within the gut itself.

The tendency of writers to explain everything on the basis of nervous reflexes and ganglionic control is unfortunate, and paralyzing to further progress.

Recent biologic work has shown in numberless ways that the main function of the nervous system is conduction.

It has been shown conclusively that the rhythmical contractions of the intestinal muscle are myogenic in origin.

Auerbach's plexus serves to conduct stimuli and to coordinate the activities of different parts of the tract. It contains no reflex arcs.

Current theories about the antagonism between the vagus and sympathetic are shown to be pseudoscientific, and out of harmony with the facts as determined by the leading anatomists and physiologists of the world to-day. The sympathetic is an integral part of the central nervous system and not an outlying antagonistic "brain."

Many of the conclusions based upon the supposed actions of drugs on nerve-endings and "intermediate substances" must be revised in the light of recent work.

The extrinsic nerves of the intestine serve to communicate between the body and the bowel, and between the bowel and the brain.

The digestive tract can work quite normally after section of all the extrinsic nerves.

The key to an understanding of peristalsis is to be found in a study of the smooth muscle in the wall of the bowel.

There are different types of muscle suited to different functions in the different parts of the body and in different parts of the digestive tract.

The properties of smooth muscle are discussed: its reactions to stimulation, to distension, inflammation, etc.

A peristaltic wave spreads both ways from a stimulated spot like ripples from a stone thrown into a pond. Most of the muscular tubes are so constructed that the ripples can travel in one direction better than another.

It may perhaps be a law for all tubular organs that the transport of material in one direction depends upon gradients of rhythmicity, irritability, tone and metabolism.

Such gradients can easily be demonstrated in the walls of the stomach and intestine.

A bolus moves aborally in the digestive tract because the pressure is greater on the upper than on the lower side. This difference in pressure is due probably to the graded characteristics of the muscle.

The peculiarities of peristalsis in different parts of the tract are explainable on the basis of local differences in the structure of the neuromuscular mechanism.

It is shown how the gradients may be upset in disease, and how these theories can explain pathologic phenomena.

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PNEUMOPERITONEUM OF THE PELVIS*

GYNECOLOGICAL STUDIES—A PRELIMINARY REPORT

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AND

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A VERY fortunate and brilliant stereo set of the pelvis in a case coming from another ward was the means of interesting Dr. Reuben Peterson, Professor of Obstetrics and Gynecology at the University Hospital, in this study, and it is due largely to his hearty and enthusiastic cooperation that work was undertaken on this subject and the present series of cases made possible. He immediately suggested the possibilities of this method for the illustration of clinical lectures and the study of the anatomical relationship of the normal and pathological pelvis, quite aside from the possibility of the development of any diagnostic value. As a further piece of good fortune, one of the earliest cases provided such illuminating evidence, even though it was poorly understood at the time,that a serious attempt to develop the diagnostic feature of the method was projected.

At the outset it was agreed that if the method were to have any extended usefulness the technique must be at once safe, simple, certain and cheap; and throughout we have aimed to produce a method and a procedure which can be reduced to a routine and can be carried out by the assistants in the Department of Gynecology and the lay members of the radiographic staff. Naturally, our first efforts were far from simple and still farther from certain. In the interest of safety, Dr. Peterson agreed to attend personally to the inflations during the developmental stage, and to date we have examined somewhat over forty cases without any unexpected or disagreeable complications.

At the present time we have tentatively adopted the following procedure: The patients are inflated in the examining room in the Department of Gynecology immediately at the conclusion of the regular gynecological examination and on the regular gynecological table. The inflation is preceded by an injection of Schleich's solution and the point selected for puncture is usually about one inch below the umbilicus in the median line, unless previous operative scars, evidence of adhesions, or other pathology, contra-indicate.

Carbon dioxide is taken from one of the usual commercial tanks from which a nitrous oxide bag is filled, and this bag is then connected with the needle without intervening manometers or washing or sterilizing apparatus. During inflation, the bag is held between the knees of an assistant, thereby giving complete control over the pressure as well as giving a fair indication of the amount of gas which has been injected. We have found that from 1½ to 2 liters of gas are sufficient to produce a fair inflation of the pelvis, although in certain individuals the bowel coils can still be seen resting on the anterior abdominal wall in the most dependent portion of the belly.

The patient is then turned over on the face, being held in the knee-chest position until an inclined board can be placed beneath the thighs. This board makes an angle of about 28 degrees with the plane of the table and its upper portion is cut out and rounded so that the pubis comes to lie just about the deepest portion of the notch. An 18 inch square of opaque fabric with a 6½ inch circular hole cut out of its center is laid on

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the buttocks and serves as a diaghragm. A plate changing tunnel is then placed horizontally on the table, double screen films are used, and a Coolidge portable unit, operating on the ordinary lamp circuit, furnishes the *x*-ray. An exposure of from fourteen to twenty seconds is required, and ordinarily each exposure is interrupted, being made at such intervals as the breath can be held conveniently, and the patient allowed to breath between the fractional exposures.

The tube shift is in the long axis of the body and the stereo set so produced is used as though the patient were lying on the right side.

This technique is the result of a series of progressive improvements. For instance, at first we used oxygen and brought the patients down to the *x*-ray room where they were first "screened" and then "plated." This method was entirely satisfactory from the *x*-ray point of view, but there was considerable complaint on the part of the patient for twenty-four or forty-eight hours if they attempted to move from the rigidly dorsal decubitus. Consequently a similar procedure was attempted with carbon dioxide; but it was found that if there were any unusual delay in the transportation of the patient—over several floors and down at least two elevators—the amount of gas remaining in the peritoneal cavity was insufficient to secure satisfactory plates. The portable *x*-ray machine used in the gynecological examining room seems to be a perfectly satisfactory solution of this difficulty.

We have also found that not so large an amount of gas is necessary for the inflation of the pelvis as for a satisfactory examination of the abdomen as a whole. Provided the examination can be undertaken immediately, we now believe that from a liter to a liter and a half is sufficient to inflate a pelvis of ordinary size. However, in order to be certain that all the intestines which normally lie in the pelvis may have a chance to escape, we prefer to give two liters of gas wherever the patient does not complain too seriously.

In the earlier cases there was considerable complaint, on the part of the patients, of persistence of the pain and discomfort for twenty-four to forty-eight hours. Accordingly, deflation was practiced. Since the introduction of carbon dioxide, deflation has not been necessary, and patients inflated at about 11 o'clock in the morning have taken their noonday meal in the sitting posture with complete comfort and no more reports of sleepless nights have been encountered. This is undoubtedly due to two factors: first, the more rapid absorption of carbon dioxide; and, second, to the smaller quantity of the gas introduced in the later cases. While discomfort and a sense of oppression are a constant complaint, these are not important except in cases with serious pathology in the upper abdomen or (as we suspect) with adhesions to the parietal peritoneum in the abdomen or pelvis.

For a time we introduced a short narrow helix of wire into the vagina for the purpose of simplifying the recognition of the various shadows in the pelvis by reason of the better differentiation which would result from a demonstration of the axis of this cavity. The shadow of the fundus of the uterus which in the earlier experiments was apt to be hidden in the shadow of the bladder, was thereby thrown backwards and more nearly into the axis of the pelvis and was more clearly outlined. However, because of the distortion which was introduced by the inflation of the vagina and the bulging of the posterior vaginal wall into the cul-de-sac of Douglas—almost invariably to one side of the median line—and because of the resulting distortion of the position of the uterus, this procedure has been discontinued.

It is probably superfluous to speak here of the advantages of the stereo set. However it is well to realize that the stereo effect in pelxis *x*-rays is not nearly so perfect as it is in the study of the bones or of the chest. The appreciation of depth is only possible when a definite point or a series of points is presented to the eye, establishing a definite parallax. In the case of a smoothly rounded soft tissue body of uniform density, such as we

are dealing with in the pelvis, such points are not normally found. The only lines upon which the eye can fix are the shadows of those portions of the perimeters of such bodies which are projected by rays which are tangent to the surface at these points. The depth of the fundus of the uterus appears, therefore, to lie in the position of its equator, and one gets no impression of the extent or the position of that organ above or the diffuse shadows of the abdomen. Our appreciation of the contour of this body is accordingly somewhat fragmentary and our conception of its shape may be quite erroneous. Nevertheless we believe the stereo set to be well worth while because of the ease with which the rather complex shadows of the pelvis may be resolved, the extraneous shadows excluded, and the relative position of these cross sections appreciated.

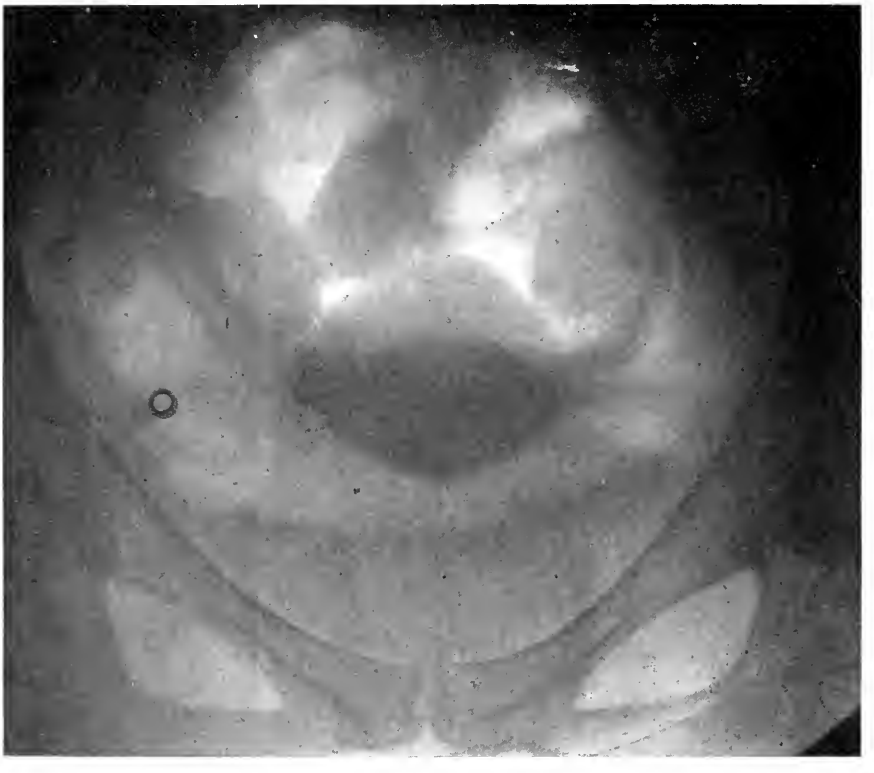

Fig. 1. Normal Pelvis. Note the optical cross sections of the isthmus and fundus of the uterus.

below that point. The image of an irregular body will be represented by a series of "optical cross sections" at the point of tangency of the projecting rays. For instance, the image of the uterus, four months pregnant, is represented only by the cross section of its enlarged cervical or supracervical portion (the isthmus) and by the shadow of the anterior surface of the neck just behind the pubis where it curves upward and extends into the abdominal cavity, while the upper margin of the body of the uterus is lost in

Our experience is obviously too limited to give an exhaustive exposition of the significance of the shadows seen. We have, however, tentatively reached certain conclusions which may be of value in the further study of this branch of roentgenographic work.

It appears that the normal pelvis is rather easily and regularly freed of all intestinal coils with the exception of that portion of the pelvic colon and the rectum which have no mesentery; and that this may be accomplished with a comparatively small amount

of gas. The shadow of the rectum is closely applied to the anterior surface of the sacrum, and as it is projected well above the shadows of the female generative system, it offers no confusion if the technique advocated is followed. It makes little or no difference whether it be full or empty. Even barium-containing feces serve only to fix the position or facilitate the orientation of the image.

FIG. 2. PREGNANCY AT SIX WEEKS. Mass on the left, possibly the ovary, with corpus luteum vera.

Whether this rule of the mobility of the pelvic intestinal coils is so invariable as to justify the conclusion that the presence of such shadows is an evidence of pathological adhesions, remains in doubt and obviously will always remain dependent upon the care exercised in the details of the technique and, in particular, upon the quantity of the gas injected. With the exception of a few cases in which the inflation obviously was insufficient, that conclusion seems to be justified by our experiences.

If a perfect degree of elevation of the hips has been attained and the direction of the ray is in the long axis of the pelvis, both the anterior and posterior pelvic pouches are empty of everything but gas. In the presence of pathology, either the one or the other may be filled with inflammatory exudate or adhesions, or incarcerated bowels and omentum, with consecutive displacement of the uterus and the broad ligaments which form the transverse partitions of this portion of the pelvis. Such displacement with obliteration of either of the pouches is one of the most striking features of inflammatory disease of the pelvis.

When entirely empty, the bladder shadow is scarcely recognized on the posterior sur-

face of the pubic bone. When distended, however, it may be seen as a rounded shadow of no very great saliency exactly where one would expect to find it, and its recognition is never a matter of great doubt.

The fundus of the uterus in a properly placed patient is separated from the bladder shadow by the space of the anterior or utero-vesical pouch which normally contains gas. ever, that the same result may be accomplished by a slightly greater elevation of the hips and a little more care in directing the ray.

On either side of the uterine shadows are seen the narrow linear shadows of the broad ligaments clearly spreading out at either end, centrally embracing the uterine shadow and peripherally fusing with the pelvic wall.

Fig. 3. Unilateral Disease of the Tube. At Operation Contained Pus.

In the presence of a marked relaxation of the pelvic floor, or where the position is not satisfactory, it may be found to lie on the posterior surface of the bladder and may be exceedingly difficult to recognize. This is particularly true in cases of senile atrophy. The introduction of a helix of wire into the vagina with the resulting dilatation of this cavity seems to help to throw this shadow backwards, more nearly into the axis of the pelvis. Our experience appears to show, how-

Where the uterus is displaced or distorted, these broad ligament shadows serve to direct one to the position of this organ. It appears that they are best seen at a level somewhat above that of the cervix, but well below the equator of the fundus.

We have never, to our knowledge, recognized the round ligaments and greatly question whether they would ever appear on the plate. We have once or twice imagined we could see them, but operation proved that

they lay in quite a different position. Careful examination of the opened pelvis gives us no reason to suppose that these exceedingly tenuous structures with their thin enveloping layers of peritoneum could reasonably be expected to show in the relatively large mass of tissues which the ordinary female pelvis presents.

The normal tubes are not seen as a separate or recognizable shadow. They apparently are component parts of the broad ligament and encroached upon by what appears to be inflammatory tissue and cicatrix.

The normal ovaries apparently are not seen. They probably lie on the postero-lateral aspect of the uterus slightly below the equator so that they form an integral part of the uterine shadow. Their position is exceedingly difficult to verify from the fact that the operation is invariably undertaken in the Trendelenburg position, while the roentgenogram is made in precisely the re-

Fig. 4. Bilateral Tubal and Ovarian Disease.

shadows. When distended or inflamed, however, they become conspicuous as tortuous shadows on the posterior surface of the broad ligament shadows, possibly obliterating them by overriding, or as pear-shaped shadows in the postero-lateral portions of the pelvis. In chronic cases the picture may be much confused by the overlying (adherent?) intestinal coils. The distortion produced may make it difficult to recognize the shadow of the uterus and almost invariably the posterior cul-de-sac is much contracted

verse, namely, the knee-chest position, and the effect of gravity would be to carry the ovaries upward rather than downward and backward. A curious observation is that the ovarian shadows are very conspicuous and easily recognized in cases of retroversion and "prolapse of the appendages," evidently being carried backward by the pathological shortening of the utero-ovarian ligaments. It is also worthy of note that a refractory retroverted uterus which cannot be replaced by ordinary manipulation appears to effect a

spontaneous reduction and is represented by an enlarged fundus almost in the axis of the pelvis and flanked on either side and posteriorly by the conspicuous ovaries closely applied to its postero-lateral aspect.

Ovaries containing small cysts have been found and recognized as ovaries although the cystic element was not recognized. Larger ovarian cysts produce a variable picture that will leave one rarely in doubt. Considerable distortion may result, as in the specific case of a young girl with a pendulous cystic ovary which hung apparently almost in the exact axis of the uterus so that the differentiation of its shadow was impossible in the imperfect state of our knowledge at that time. The unusual mobility of this cystic ovary was clearly demonstrated at operation.

The cervix and the vagina, as well as all structures in the pelvic floor which lie below the level of the peritoneal pouches behind the broad ligament, are entirely undifferentiated, and it is entirely probable that considerable infiltration of the soft tissues in this neighborhood will leave no recognizable evidence. The insertion of a helix into the vagina serves to fix the position of this cavity and the direction of its axis; but pathology in this neighborhood, such as carcinoma of the cervix, may be expected to escape detection entirely except in so far as it encroaches upon the structures above the deepest portions of the cul-de-sac.

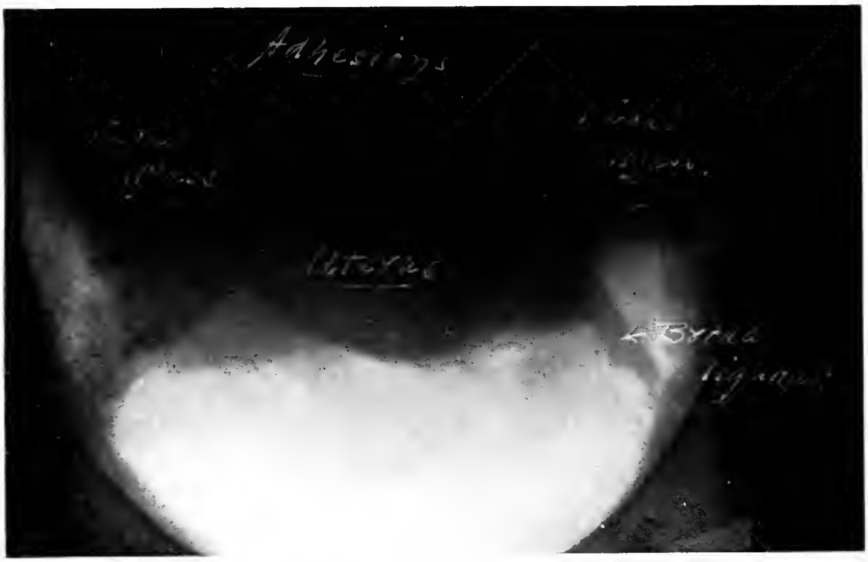

Fig. 5. Chronic Pelvic Inflammation. Note the obliteration by adhesions of the posterior cul-de-sac and the distortion of the broad ligaments.

Enlargements and tumors of the pelvic organs cast conspicuous shadows and often rise into the abdomen. We are not yet ready to formulate any comprehensive set of rules for their differentiation, because of the paucity of our data. We tentatively offer the observation that the pregnant uterus casts a shadow less dense than myomata. One gets the impression of a high degree of elasticity, and the enlargement of the isthmus, or supracervical portion, of the uterus as seen in cross section, as well as the broadening of the broad ligaments, is more conspicuous in pregnancy than with tumors. Incidentally the shadow of the fundus of the uterus is not differentiated once it is out of the true pelvis, although its anterior surface at the plane of its inflection can sometimes be seen immediately behind the pubic bone. In fibroid of the uterus, on the other hand, the cross section of the isthmus is not enlarged, the mass has considerably greater density, and does

not appear to be flattened out as in the case of the pregnant uterus.

It would be an obvious error to attach any great weight or authority to the above hasty generalizations on so few observed cases. We have found that a diagnosis is anything but easy, and continue to meet with a discouraging number of disappointments. The findings, however, are so striking and the stereoscopic picture so intriguing that we cannot refuse to entertain the hope that reliable criteria of interpretation will be developed by a continuation of these studies. Both Dr. Peterson and myself are planning later communications on the results of this work as soon as reliable conclusions seem justified.

Even though the method can be developed to the point where a reliable judgment is possible on the part of the roentgenologist, it is not at all certain that his opinion will be of material diagnostic assistance to the gynecologist, since he, the gynecologist, is already fairly competent to reach a satisfactory conclusion by bimanual palpation. However, several instances in which interesting, if not essential, information was obtained, seem to warrant the expectation that the method will find a legitimate application in selected cases and furnish a common interest with still another specialized branch of modern surgery with which we, as roentgenologists, have heretofore found few points of contact.

[NOTE. The discussion of this and other papers relating to Artificial Pneumoperitoneum presented at the Twenty-first Annual Meeting will follow the publication of the entire series.]

THE TREATMENT OF CARCINOMA OF THE BREAST BY IMBEDDING RADIUM SUPPLEMENTED BY X-RAY*

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IN all the progress made in recent years in radiotherapy, nothing has been evolved of such significant import in the treatment of carcinoma of the breast, as the advanced method of imbedding radium, with its manifold and varied advantages and possibilities in deep therapy. By imbedding radium throughout the entire breast, in the axilla, into the glands leading from the breast to the axilla and into the glands below the clavicle, it is now possible to make radiation for carcinoma of the breast as thorough as a radical dissection without opening the lymph channels. Supplementing Coolidge *x*-ray treatment to the twenty or more lymphatic chains draining the breast, using 10 mm. of aluminum and cross-firing as much as possible, there is completed the most advanced and most effective treatment, which is in marked contrast to the treatment given fifteen or twenty years ago with a comparatively low penetrating gas tube, using no filtration or meters for giving exact dosage, and thus administering only superficial radiation when deep treatment was necessary.

In the early days of radiotherapy a deep lethal dose could not be given without producing superficial ulceration or necrosis. By imbedding radium a lethal dose can be given without any effect on the skin. Besides the subcutaneous tissue will tolerate from three to five times as much radiation as the skin. The result of radium in malignancy depends upon whether a lethal dose is given. Formerly it was concluded, because our best radiograms were taken with comparatively low tubes, that this form of radiant energy was the most suitable for deep therapy. Almost every one overlooked the loss of energy by absorption in the tissues and by divergence of the rays, and practically nothing was known about the lethal dose of different types of malignant cells. Most radiologists compared everything with the amount of radiant energy necessary to destroy rodent ulcer; and when the squamous cell epithelioma, axillary nodes and a cancerous mass in the breast did not disappear under *x*-ray, the radiation was considered useless. The real fact was that a lethal dose had not been given.

Radiation for the treatment of carcinoma of the breast has been so changed by imbedding radium that where only superficial skin effects were formerly produced, now cancerous tissue deeper than that which can be removed by the knife can be destroyed without opening the lymphatic chains. Before imbedding radium I always give surface applications in the axilla and over the glands below the clavicle, and I give a complete course of heavy filtered *x*-ray treatment to the breast and all the glands draining it. This checks cell proliferation and lessens the danger of metastases when the breast and adjacent lymphatics are speared and radium inserted. It is generally agreed that it requires from two to four weeks to check cell proliferation. It has been shown that the lymphatics begin to undergo a fibrosis at the end of the fourth week and that the caliber of the lymphatic vessels are smaller than before treatment was given. It seems just as advisable to give surface treatment before imbedding radium as before operation. Some few surgeons are now advising ante-operative treatment, and if they would include imbedding radium and remove less tissue, thereby leaving the sclerosed lymphatic tissue as a barrier against cancer cells, I feel

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sure that the end results would be better, at least in borderline cases; that is, there would be fewer recurrences, and if a recurrence did take place it would be considerably later than when the operation precedes radiation.

Imbedding radium in the treatment of carcinoma of the breast is a step in advance, but the number of cases treated by this method are not sufficient and its use is of too short duration to speak about anything but temporary results. Even in some of the advanced cases the disease in the breast and the glands appears to have retrogressed, clinically. Of course in some cases there is still thickening due to the fibrosis from the radiation. Not enough cases have been operated upon to give definite histological changes. In the inoperable cases we were inclined to leave well enough alone, and in the early cases each one has refused operation. My advice has been, even in the advanced cases, where the disease has clinically receded, to have the breast removed without opening the axilla; but to my extreme disappointment, in almost every advanced case that I turned over to the surgeon he opened the axilla, and when the patient returned, almost without exception she had a swollen arm and was in much worse condition than before operation. I feel sure, however, that if we could have the surgeon remove only the breast, thereby taking away the unhealthy mammary gland, the patient would be greatly benefited. I am speaking of the advanced or inoperable cases which have had thorough radiation, and not the early cases which we are advising to have anteoperative radiation. Imbedding radium as described takes the place of operation in advanced cases, and as before stated, the removal of the breast is all that is advised.

It is imperative that every therapeutist should make a comprehensive study of the lymphatics draining the breast before he attempts to treat mammary carcinoma. The lymphatic supply to the breast is greater than to almost any other organ of the body. A study of the lymphatic and bone metastases will show that although the case is operated on early, the raying of the line of incision, axilla and supraclavicular region is very incomplete.

Deaver's classification in regard to end results are probably as near correct as that of any other author and should be studied by the surgeon and radiotherapeutist. He says: "It has been stated that 80 per cent of patients in whom the disease is confined to the breast, as proved by both microscopic and macroscopic examination of the tissues adjacent to this organ, are permanently cured of their disease by the radical operation. Therefore, a patient presenting a small movable mass localized in the breast can be assured that four out of five cases of a similar nature are cured by operation. When axillary lymph nodes are palpably enlarged as the result of metastases, the chances of operative cure are at once diminished to one in five."

This deduction is practically the same as that of Halstead, who says that, notwithstanding the present day extensive operation, death from metastases occurred in 23.4 per cent, even in cases with a microscopic negative axilla. Deaver questions whether as much palliation is received from operative as from non-operative methods, and expresses his general dissatisfaction with operation of a palliative nature in the treatment of carcinoma of the breast, since in certain cases the disease has been excited to greater activity by an incomplete operation, and the life of the patient considerably shortened.

In this connection he mentions the unreserved statement of Bloodgood, "that incomplete operation hastens death."

The above quotation which is taken from Deaver's carefully prepared volume, "The Breast, its Anomalies, its Diseases and their Treatment," should receive more attention from the medical profession.

The prognosis and treatment of mammary carcinoma can be estimated only after consideration of many factors. Hanley considers operation contra-indicated when there is extensive ulceration and when the tumor is adherent to the chest wall; when axillary

nodes are flexed; when there is supraclavicular involvement and when there is indication of distant metastases. When the axillary glands are palpable there are very few cures by surgery alone without radiation, even when the axillary nodes are not palpable; and when the glands are found to contain cancer cells microscopically only about 20 per cent of the cases are cured at the end of five years. Greenough claims that when the axillary nodes are palpable, 12 per cent were cured by operation, and Finsterer stated 4.3 per cent. Ewing believes the latter represents the average success by surgery, which means that a woman who has a well established cancer of the breast, with palpable axillary nodes, has one chance in twenty-five of being cured by operation. Therefore, in cases of this class it is not too much to advise imbedding radium and giving a thorough course of radiation before the removal of the breast.

The clinical and pathological studies of cancer of the breast have shown that both surgery and radiotherapy meet with many difficulties and uncertainties. The anatomical types are so many, the variations of the clinical course are so wide, the paths of dissemination so diverse and the difficulty of determining the actual condition so complex, that giving a lethal dosage is difficult. Since Deaver and Bloodgood both claim that an incomplete operation hastens death, there is good reason for advocating the imbedding of radium into the breast and into the adjacent lymphatics wherever possible. A study of autopsies shows that almost any organ of the body may metastasize from cancer of the breast, and however closely confined to the superficial tissues the growth seems to be, no one can tell where the cancer-growing edge may extend; although unappreciable by ordinary methods of examination, it is just as definite as ringworm. This shows us that even in the early cases no lymphatic chain should be omitted when raying the lymphatics with a Coolidge *x*-ray tube, and as much cross-firing should be used as possible. In an article which I read before this society in 1917, I described the glandular distribution of the breast and the method of raying with a Coolidge *x*-ray tube. Since then I have been using 10 mm. of aluminum, giving from fifteen to twenty minutes' exposure. At that time I made the statement that "we are all looking for some means by which the skin will tolerate larger doses." This has to a certain degree been accomplished by imbedding radium and using heavier filtered *x*-rays.

After cancer cells have reached the axillary nodes, the disease soon becomes generalized, and tissue in almost any part of the body may become involved. If we had an *x*-ray microscope and it were possible to give a lethal dose to all cancer cells, the end result would be different. When it is impossible to give a lethal dose, palliation and prolongation of life is obtained in nearly all cases. Less than a lethal dose will usually stop cell proliferation, produce a fibrosis of the lymphatics and obstruct or obliterate the lymphatic vessels, thereby checking cancer dissemination. In fact, radiation changes the character of the disease, transforming it into more of a scirrhus form, by decreasing glandular cells and increasing the fibrous stroma. This mechanical choking clinically seems to influence the constitutional resistance of a patient. The same difficulty is not encountered in giving a lethal dose when radium is imbedded in cancerous tissue as when deep seated metastases are treated either by surface applications of radium or *x*-ray.

In calculating the filtration and the number of ports of entry or the amount of cross-firing necessary to give a lethal dose to metastatic lymphatic glands, it is necessary not only to know the anatomical situation, but we must know the depth and density of the overlying structures. It makes quite a difference whether the glands are situated one-half inch or four inches from the surface. The erythema dose in carcinoma of the breast is very seldom the lethal dose. The lethal dose is from three to six times the amount of the erythema dose. Therefore, if a surface erythema dose is given and the

disease is four inches below the surface of the skin, the loss of radiant energy by divergence of the rays and absorption of the tissues with an *x*-ray tube placed eight inches from the surface with the equation used, is about one-ninth; or in other words, only about one-ninth of the surface radiation reaches four inches below the surface of the skin. Then if the lethal dose is from three to six times the erythema dose, it can be readily seen that when only one port of entry is used the treatment would be useless. Formerly, too many were satisfied with the removal of the visible part of the disease. The degree of malignancy is no guide to the amount of radiation determining its lethal dose. On account of rodent ulcer growing slowly and responding to small amounts of radiation, these circumstances led many to believe that a lethal dose was determined by the degree of malignancy of a tumor. Medullary carcinoma may respond more readily to radiation than the scirrhus type, but it grows more rapidly and invades the glands early, so if a cure or even an inhibitory effect of the disease of this type takes place, both the local tumor and metastases must be given sufficient radiation. If results are going to be produced in the medullary type, the cancer cells must show effect within three or four weeks, and fibrous tissue must be forming at the end of this time. In the scirrhus type, the fibroid formation has already taken place by nature's process.

When we speak of the lethal dose of radiation, we refer to direct action on malignant tissue; but there is an indirect effect of radiation on malignant cells by the formation of fibrosis which starts to form three or four weeks later. Both are important, and a lethal dose should be given whenever possible, but less than a lethal dose sickens the malignant tissue, as Mayo expresses it, and starts the formation of fibrous tissue which is a barrier against the disease. In locations where radium can be buried a lethal dose can nearly always be given, but in the treatment of deep metastatic glands we may be compelled to depend upon both the direct and indirect effect of radiation on malignant cells. Therefore, when carcinoma of the breast is so far advanced that a cure cannot be expected, the patient should have all the palliation possible from both the direct and indirect effects of radium and *x*-ray.

In a tumor that does not respond readily to radiation there is more necrosis and less absorption when a lethal dose is given. In two cases in which the mass in the breast was hard and of long duration, the growth was walled off, and when the breast was speared, broken-down non-offensive material came out through the trocar. This was due to heavy surface applications of radium. In each of these cases a clinical cure was obtained after imbedding radium, and the normal tissue was not injured in either case.

The ability to classify cases requires clinical experience and forms an important part of the training of the radiologist. The question of large dosage altering normal tissue after the reaction has disappeared is an important factor, and this alteration of tissues will not permit the normal tissue to bear so well a second, third or fourth exposure. The normal tissues are usually injured by a frequent repetition of the radiation, while the cancerous tissue, if any remains, may not retrogress in a proportional degree. In fact, the cancer cell and normal tissue may react in about the same degree, or there may be a reversal of the primary susceptibility. This shows the advantage of imbedding radium wherever possible after a maximum surface dosage has been given.

The method I have adopted is to give a thorough course of Coolidge *x*-ray treatment to all the glands draining the breast, using the following equation: 10 mm. aluminum, 8 inch tube distance, five milliamperes of current, nine inch spark-gap and from fifteen to twenty minutes' exposure. A constant voltage is difficult to obtain. The pastille erythema dose is very unreliable and is not as accurate as the milliampere dose, using the different types of transformers with a fluctuating voltage. Calculations based upon false assumptions have been very misleading, and

in giving a lethal dose exact standards must be employed. In many of the cases the breast and axilla receive a maximum dose from radium packs before imbedding radium.

Two or four weeks after surface applications I have been imbedding 10 mg. radium needles (vanadium steel needles, thickness of wall .35), placing them 1 cm. apart, and giving from five to eight hours' exposure. In some cases this produced a slight inflammatory reaction, but in no case has necrosis taken place. I may say that I started over three years ago—most reluctantly—to imbed radium in more superficial lesions; I can now indorse this technique as presenting many points of advantage over surface application in the treatment of many forms of malignant lesions, but it will not take the place of the Coolidge *x*-ray tube in the treatment of distant and deep metastases.

[NOTE. The discussion of this and other papers relating to Therapy presented at the Twenty-first Annual Meeting will follow the publication of the entire series.]

DISLOCATION OF THE CARPAL SCAPHOID

By T. S. BONNEY, D.D.S

ABERDEEN, SOUTH DAKOTA

THERE is very little to be found in the literature relative to dislocations of the carpal bones except that the condition is very rare; and the following case seems worthy of report for that reason. I was privileged to make the *x*-ray plates of this case through the courtesy of Dr. C. E. McCauley of this city.

Mr. L. J., age twenty-one, suffered a fall from a horse on October 15th, striking on his right hand, and was seen by Dr. McCauley October 17th, at which time the *x*-ray examination of the wrist was made by myself.

The accompanying cuts show clearly the dislocation of the bone in question.

FIG. 1. SHOWING DISLOCATION OF THE RIGHT CARPAL SCAPHOID.

X-RAY TREATMENT OF TONSILS AND ADENOIDS

By W. D. WITHERBEE, M.D.

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NEW YORK CITY

FOLLOWING the suggestion of Dr. J. B. Murphy,[1] I treated the first case of hypertrophied tonsils in December, 1919, at the Rockefeller Institute for Medical Research.

This case, although carefully examined, revealed no changes in the surface size or outline of the tonsil, until the fifth week following treatment. The first evidence of the effect of *x*-ray was a smoothing out of the tonsillar mucous membrane, which very soon resulted in a glazed and somewhat pale surface.

This was followed by a rather rapid decrease in size, which in this case was most apparent in the left tonsil. At the end of eight weeks the left tonsil was seemingly reduced one half and the right one third.

About this time a dose similar to the first was given. Since then and up to the present time this patient has had no further trouble and the tonsils are apparently now both about one fourth the original size.

As soon as the effects on this case became conclusive Dr. S. L. Craig and I started a series of cases which numbered in all about sixty and ranged in age from sixteen months to fifty years.

In this series every patient was required to report for examination weekly. The history of each case was taken, a blood count made, the contents of the crypts plated and colonies of bacteria counted. A drawing of the throat and tonsils was made and notes were taken each time in regard to the progress of the case. Very few of these cases received more than one treatment, as we wished to determine the time necessary for the *x*-ray effects on the tonsil, and thus decide on the number of treatments required in a given case.

The amount of *x*-ray used in the experimental series of sixty cases varied from three to seven minutes time, depending on the age of the patient, with an 8 inch spark-gap, 5 milliamperes and 10 inches distance, filtered through 3 mm. of aluminum. This dose of filtered *x*-ray is less than the standard amount used for the past twenty years in the treatment of ringworm of the scalp in children, which fact overcomes the possible objection of any untoward effects on adjacent tissues from the standpoint both of amount, and of area of the head exposed.

In ringworm of the scalp five exposures are necessary in order to obtain uniform results of epilation. Only two exposures are necessary in each treatment of tonsils, and the maximum dose used is 1¾ skin units [3] of filtered ray, which corresponds to less than 1 skin unit used in temporary epilation of the scalp in children. It is generally conceded by most writers on this subject that the increased size of the tonsil depends directly upon the increase of the lymphatic tissue. The follicles appear larger than normal, are less sharply outlined, and usually the germinal centers are quite prominent and contain numerous mitotic figures. Occasionally the lymphoid cells appear to overflow into the interfollicular structures. According to Kellert [2] the hypertrophy of the follicles appears to cause distortion of the crypts, thus aiding in retention of the crypt contents.

The effect of *x*-ray on lymphoid tissue in the diseased tonsil is exemplified in the diagrammatic representation Figure 1. The destructive action of *x*-ray on the cells of the lymph follicles of both the lymphoid and fibroid tonsil are also well outlined.

The sections taken from an enlarged tonsil (Fig. 2) and the two made of tonsils enucleated eight weeks and four months after one massive dose of *x*-ray (Fig. 4) indicate the cause of the shrinkage of the tonsil and expulsion of crypt contents.

The selective action of *x*-rays on embry-

onic tissue or its effect on the cell in certain phases of mitosis are the usual methods of describing *x*-ray effects on diseased cells as compared with normal cells.

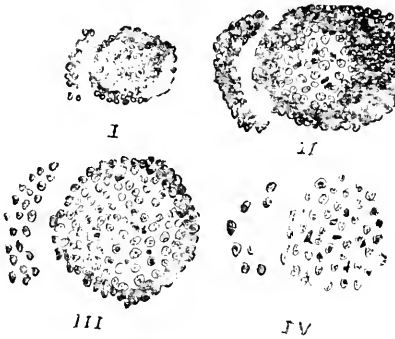

FIG. 1. I. Standard Lymph Follicle. II. Lymphoid Hypertrophy. III. Fibrous Hypertrophy. IV. Effects of *X*-Ray on Lymph Follicles.

The destructive action of *x*-rays on the cells of these enlarged lymph follicles might also be explained on the ground of their having been stimulated to excessive cell proliferation to such an extent that there remains less resistance to the *x*-ray than in the normal cell. Therefore this difference in resistance would account for the small dose of *x*-ray necessary to destroy these pathogenic lymph follicles without interfering in any way with the normal adjacent cells.

The bacteriological report embodied in the following table indicates the possibilities of the bacterial cryptic contents after one massive dose of *x*-ray. This case and a few others examined three months after *x*-ray treatment, showed negative cultures for pathogenic bacteria. The results in all cases were not as clean-cut as in this case. This might be explained by the fact that in passing the platinum loop into the crypt no method has as yet been devised whereby the surface of the tonsil can be rendered sterile in order

TABLE I

March 3, 1920

Right Tonsil,	24 hrs.,	50	Colonies	of	Hemo.	Strep.
" "	48 "	100	"	"	"	"
		50	"	"	"	Staph.
Left Tonsil	24 "	50	"	"	"	Strep.
" "	48 "	50	"	"	"	"
		50	"	"	"	Staph.
Vault	24 "	50	"	"	"	Strep.
"	48 "	50	"	"	"	"
		150	"	"	"	Staph.

March 17, 1920—2nd Week After X-Rays

Right Tonsil,	24 hrs.,	No	Colonies	of	Hemo.	Strep.
" "	24 "	"	"	"	"	Strep.
		No	"	"	"	Staph.
Left Tonsil	24 "	"	"	"	"	Strep.
" "	48 "	"	"	"	"	Strep.
		No	"	"	"	Staph.
Vault,	24 "	No	"	"	"	Strep.
"	48 "	"	"	"	"	Strep.
		No	"	"	"	Staph.

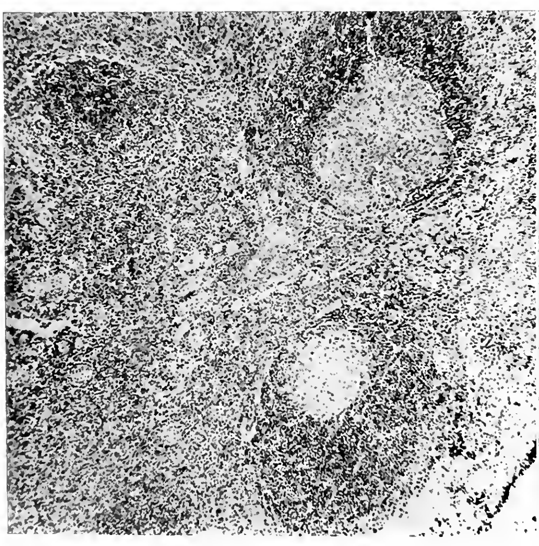

FIG. 2.

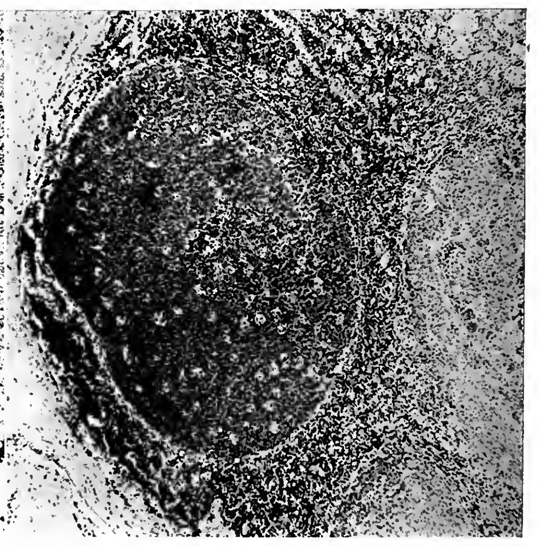

FIG. 3.

to avoid contamination from the mucous membrane. However, this can readily be accomplished with enucleated tonsils by dipping them for one minute in boiling water. Thirty-two out of thirty-six cases showed negative cultures for pathogenic bacteria four weeks after one massive dose of x-ray.

Figure 5 illustrates the diminution in size and characteristic changes in the surface of the tonsil at various periods of time after one massive dose of x-ray.

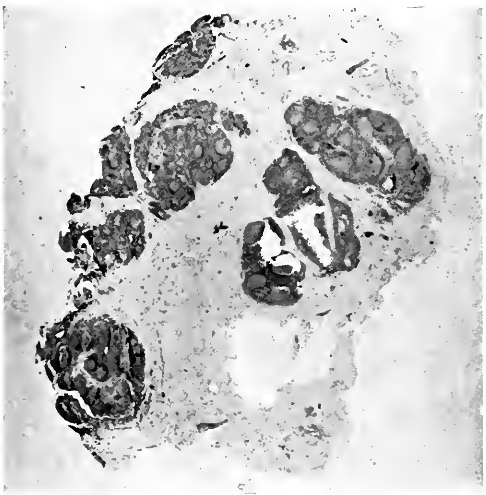

Fig. 4.

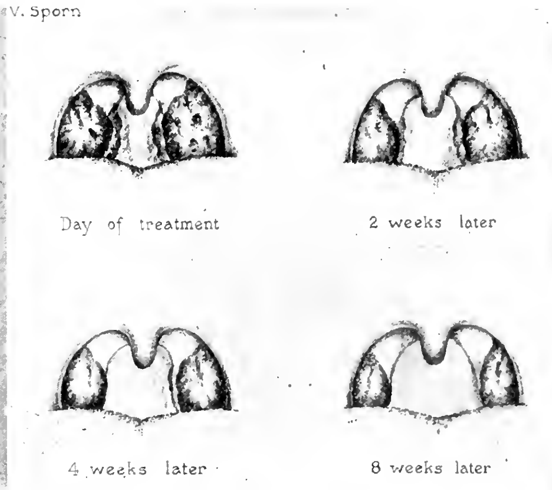

Fig. 5.

x-RAY TECHNIQUE

Figures 6 and 7, illustrating the position and immobilization of the younger patients give a much better idea of the practical application of the x-ray than the most accurate description. Figure 6 represents a board 4 feet long, 10 inches wide and 1 inch thick over all. The longest piece for the support of the body is 3 feet. The head piece is 1 foot by 10 inches and 1 inch thick with a bevelled opening 2½ inches in diameter. This opening prevents undue pressure and discomfort of the ear. The distance from the table level to the apex of the angle made by the union of the head piece and body support is 3½ inches. This angle and inclining head board not only give the position necessary for the direct exposure of the adenoids and left tonsil as shown in Figure 7 but also include the right tonsil and adenoids as the rays pass on through the opposite side of the head and neck.

This position can be assumed by the adult patient with the proper placing of pillows or cushions without the use of restraining straps and board so essential in the treatment of young children.

By maintaining the above position and placing the x-ray tube at the proper angle in both children and adults it is evident that each tonsil and the adenoids receive two doses of x-ray.

The opening in the lead foil, as in Figure 7, should be not less than 3 inches by 2½ inches for the average case. Figure 8 represents the area of exposure, and illustrates the area and position of the patient when a third exposure is considered necessary for cases with extensive growth of adenoids.

DOSAGE

In the experimental series of sixty cases treated at the Institute the following factors were used with 3 mm. of aluminum: 8 in. Sp. Gap. 5 M A 10 in. D and from 3 to 7 minutes time for each exposure depending on the age of the patient.

From the experience with these cases and

subsequent treatment of other cases, fractional dosage seems to promise better and more uniform results than the single massive dose used in the above series.

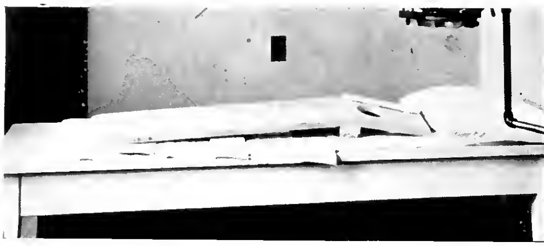

Fig. 6.

It therefore seems advisable to give each case at least four treatments as a minimum using the following factors every two weeks: 7 in. Sp. Gap. 5 M A 10 in. D and 3 min. 18 sec. time through 3 mm. of aluminum. These factors give 1 skin unit of filtered ray, which

Fig. 8.

corresponds to ½ skin unit unfiltered in effect on the skin. The same result may be obtained by producing 1 skin unit of filtered ray with a 6, 8 or 9 inch spark gap [5] 5 M A 10 in. D with 3 mm. of aluminum, or if necessary 1 mm. of aluminum could be used instread of 3 mm. to save time, especially with the small (2 K W) interrupterless machines where a 6 inch gap is maximum. The factors for 1 skin unit with 1 mm. of aluminum would be 6 in. Sp. Gap 5 M A 10 in. D and 2 min. 41 sec. time.[3]

The next best method would be two or three massive doses given with four to six weeks intervals.

DANGERS OF FAULTY TECHNIQUE

Before leaving the subject of dosage it is necessary to point out clearly that anyone

Fig. 7.

contemplating carrying out this technique who does not thoroughly understand the part played by each of the four factors of dosage and who has not mastered his machine and tube so that all four factors are constantly maintained throughout the exposure will sooner or later produce an x-ray burn with its consequent permanent deformity and tendency to epitheliomatous degeneration. The only contra-indications to the immediate use of x-ray are: recent radiographs of the region to be exposed; recent x-ray treatment; the external application of any liniment, ointment or lotion other than vaseline, lanolin or cold cream. It does not seem advisable to give x-ray treatment during the active stage of an acute infection or immediately after applying nitrate of silver, iodine or any local irritant to the tonsil.

With the present day methods of measuring x-ray dosage and the constancy of the Coolidge tube and interrupterless machine, the dangers of the gas tube and the x-ray coil are practically eliminated. A Doctor's degree, years of experience in nose and throat, or even in radiography (x-ray plates), do not au-

Fig. 9.

tomatically fit any one for the practice of x-ray therapy.

On the other hand if the treatment is properly given as indicated, and the time lessened in both the massive and fractional methods of dosage in accordance with the age of the patient, there is not the slightest danger of injuring the skin or any of the adjacent structures, as exemplified in the results obtained for the past twenty years in the treatment of ringworm of the scalp. The immediate and after-effects of excision of the tonsil seem severe as compared with the x-ray treatment, which may produce dryness of the throat and a feeling of stiffness in the muscles of the neck. These symptoms are only apparent to the sensitive individual when the massive dose is used.

The extent of any after-effects of discomfort might be explained by citing the case of a young man to whom I gave three massive doses between 4 and 5 P. M., and that night he won the one-mile amateur championship in a local armory.

Recently Dr. Thomas R. French [4] has emphasized the presence of chronic infectious material in the crypts of the infratonsillar nodule as a possible source of systemic infections, and advocates their removal even though the operation is more extensive than that of tonsillectomy.

The infratonsillar nodules or tonsillar branches (Fig. 9) may overlap the under surface of the posterior lateral halves of the inferior lobes of the tonsil.

Those structures frequently referred to as infiltrates or recurrent tonsils are really nothing more than extended and expanded ends of these lymphoid bodies. The fossa, or space between the pillars left after removal of the tonsil, may be subsequently filled by the infratonsillar lymph nodule with its infected crypts. The infratonsillar nodes may progress in size as the tonsils themselves diminish or atrophy. Those nodes in some cases may be larger than their associated atrophied tonsil.

If the infratonsillar nodule with its pharyngeal and lingual branches (Fig. 9) exhibits all the characteristics both pathologically and histologically of the tonsil as indicated in the above article [4] with the results so far obtained with x-ray on tonsillar tissues, does it not seem reasonable to infer that not only will cases treated with x-ray have their tonsils reduced and crypts evacuated, but that the same process will prevail in the infratonsillar nodule, thus more thoroughly removing the focal infection than by tonsillectomy and that by this means better results will be obtained in combating those systemic infections dependent on this condition, namely, rheumatism endocarditis, chorea, septicemia, etc.?

The results of the study thus far open up possibilities of the x-ray in connection with tonsillar disease. One hopeful assistance is in the diagnostic value in determining the relationship between the focus and a given systemic infection, more especially those infections in which pain is a prominent symptom. If the bacteria are the causative factors of such pain, it would stand to reason that their evacuation would be followed by partial or complete relief. In such an event the most rational treatment could be definitely decided upon. Another hopeful assistance from the x-ray is to be considered in the possible evacuation of bacteria from the crypts of the tonsil in carriers, especially those of diphtheria and influenza. For it is hardly to be supposed that these bacteria would recur after such evacuation except by reinfection.

CONCLUSIONS

It would seem probable that x-ray treatment will be indicated in cases of diseased tonsils and infratonsillar lymph-nodes associated with chronic endocarditis pericarditis, hemophylia, or any co-existing conditions which contra-indicate operation or an anesthetic.

We know that after tonsillectomy in subjects above the sixth or eighth year, and especially in adults, there still remains a considerable and possibly a vast amount of diseased lymphoid tissue containing pathogenic bacteria, in which cases it would seem reas-

onable to believe that the x-ray will prove to be of value.

It must be understood that this paper is only suggestive, and that the permanency of the results time alone will determine. But the facts in so far as the experimental work has been carried out are presented.

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AN INEXPENSIVE RADIUM CAPSULE HOLDER

By GEORGE E. PFAHLER, M.D.

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THERE is much risk in handling the capsules containing radium element, and in the process of screwing these capsules together or separating them there is unnecessary exposure of the fingers to danger. Any device that will help to keep the fingers at a distance will be useful and will lessen damaging effects. Several capsule holders have already been designed, but each one will fit only the capsule for which it has been made. I therefore searched in instrument stores and elsewhere, but finally went to the hardware store where I found a chuck which is 10½ cm. in length and which can be adjusted to take any of the capsules varying from 4 to 6.3 millimeters. The cost of this chuck is 85 cents, plus the labor of drilling the soft jaws. It is necessary to drill out the chuck in its central portion so that when it is wide open it will just grasp the largest sized capsule. This chuck is superior in my experience to the instruments made costing $12 to $15. It can be lengthened as much as desired by setting the handle into a wooden handle (Fig. 1). The remainder of the metal, if desired, may be covered with rubber. Having just spent twenty-five dollars for a pair of instruments that will not even grasp one size of capsule satisfactorily, I naturally "enthuse" over the above little instrument.

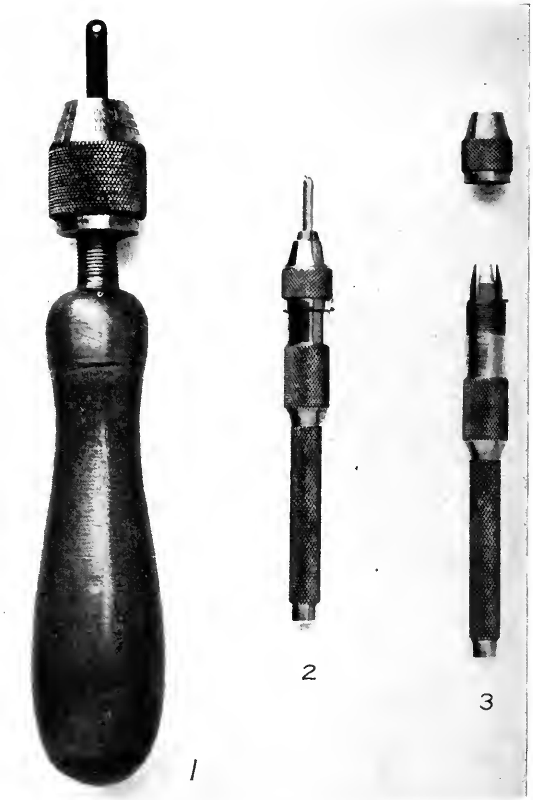

Fig. 1. Goodell Pratt Co. Second Size Drill Chuck. Will take any size capsule. Wood handle can be attached as shown in this figure.

Fig. 2. Starett Pin Vise Grasping one of the Radium Capsules.

Fig. 3. The Same Pin Vice with Cap Removed, showing the jaws which have been drilled out sufficiently to take varying sized capsules.

TWO UNUSUAL CHEST CASES*

By JOHN G. WILLIAMS, M.D.

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CASE 1. *History*.—First seen by Dr. A. A. Rutz, April 11, 1917. Female, age forty-eight. Married, and prior to her marriage a public school teacher.

Past History.—Fifteen years ago she had malaria, and ten years ago typhoid fever. She had never had diphtheria. There have never been any paralyses. Her menstrual history is negative, except that recently the periods have been prolonged.

She has always been of nervous temperament and suffered from gastro-intestinal disturbances. She was irritable and subject to emotional attacks of crying and laughing. These attacks in later life were followed by mental and physical prostration, necessitating rest in bed. At various times she has suffered from pain in the back of the neck and numbness and pain in various regions of the body. There was also insomnia and impairment of memory. She has always been constipated. Excessive secretion of saliva has been noted for years.

Fourteen years ago the patient saved a child from strangulation, a particle of food having entered the child's respiratory passage. This incident impressed itself so firmly on the patient's mind that, from this time on, she suffered from a constant fear of choking during her meals. At times this fear became so strong that it interfered with her deglutition. These disturbances of deglutition were always slight and transitory in character and consisted of sudden regurgitation of food from the esophagus, occasional coughing and choking, and the entrance of food into the nares. Her chief complaint at the time she consulted Dr. Rutz was belching of gas.

Physical examination at this time showed a few râles at the base of both lungs, a palpable right kidney and tenderness over the cecum and ascending colon. The knee-jerks were exaggerated.

On April 20th a test breakfast was given, following which a stomach tube was introduced and the contents of the stomach removed without difficulty.

On April 21st a test dinner was given to determine the gastric motility. A No. 23 French stomach tube was introduced without difficulty, but aspiration was impossible, and inflation showed that the tube was not in the stomach. The tube was removed and again inserted, with the same result, but it was noted that air passed through the tube with respiration. From this it was deduced that the tube was in the trachea and was removed. The patient was asked to swallow, but was unable to do so, as evidenced by failure of the larynx to move. Further examination showed that there was complete anesthesia of the pharynx and larynx. The gag reflex was absent and the insertion of the tube into the trachea caused no reflex cough or discomfort to the patient. The difficulty in deglutition was, at that time, considered temporary and unimportant, and was attributed to the patient's nervous condition, as she had looked forward to the examination with considerable apprehension.

On April 27th Dr. Rutz was called to the patient's home, as her condition had assumed a more serious phase. She was found sitting up in bed, suffering from considerable dyspnea and cyanosis, and imbued with the idea that her dyspnea was due to distention of her stomach. She was belching large quantities of air.

Examination of the abdomen showed no undue distention of the stomach. There was a large number of coarse mucous râles over both lungs. The physical signs in the chest were suggestive of pulmonary edema. Temperature, 101.6. Pulse, 130. Respiration, 36.

The patient was given water to swallow, but no deglutition sounds could be heard at the ensiform. Following this, the dyspnea

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY, 1920.

and other chest signs increased. The cause, nature and seriousness of the patient's condition were recognized. The disturbance of deglutition previously observed had persisted so that her food was entering the trachea, and thereby interfering with respiration and subjecting the patient to the danger of pulmonary infection. Dr. Rutz now sent the patient to St. Mary's Hospital for treatment and observation. Rectal feeding was resorted to at first and later it was found possible, by

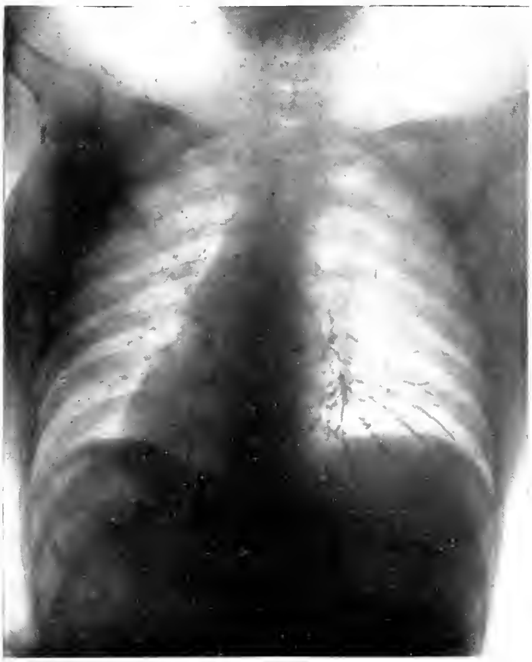

FIG. 1. CASE 1. Bismuth in Both Lungs and also in Larynx.

the use of a stiffer tube, to pass the same into the stomach, and the patient was fed in this way. Excessive secretion of saliva was a constant symptom at this time, but was controlled by belladonna. Her pulmonary symptoms rapidly cleared up and later her respiratory passages showed a marked tolerance to foreign material of various kinds. Various colored solutions were given and later coughed up. At one time six ounces of custard were apparently retained in the respiratory passages for twenty minutes and then gradually brought up by coughing.

On May 10th the writer examined the patient at the hospital. Two ounces of bismuth mixture were given the patient to swallow, and on the screen it was seen that most of this entered the trachea and thence on into the bronchi of both lungs. It apparently caused the patient no distress, and she did not cough as a result of it. Stereoscopic plates were then made, and it will be seen from these that the bismith mixture entered the lower lobes of both lungs extending well out into the smaller bronchi. Some few hours later, the patient coughed up much of the bismuth, and two days later the stereoscopic plates showed no trace of it in the respiratory tract.

For three weeks during her stay in the hospital complete aphagia was present. At the end of this time the patient began to swallow normally with occasional remissions, so that at times she had to be fed by tube. She was allowed to return home after four weeks' stay in the hospital, and a member of her family was instructed how to pass the tube and tube-feeding was continued for some time after leaving the hospital. The aphagia suddenly ended when one morning, at breakfast, she had an uncontrollable desire to drink some tea. She drank three cupfuls in succession, and from this time on had no difficulty in swallowing. When last seen, December 1, 1917, she was swallowing in a perfectly normal manner. Sensation had returned to the pharynx and larynx and none of her former symptoms were present.

The diagnosis in this case, made by Dr. Rutz before referring the case to the writer, is hysterical aphagia. The loss of sensation in the pharynx and larynx eliminated the second stage of deglutition, and the larynx was not elevated and protected by the epiglottis, so that, through gravity, the material swallowed dropped directly into the larynx. The retention of foreign material for so long a time in the bronchi indicates that there was diminished sensation here also. Difficulty in deglutition is not uncommon in hysteria and is mentioned in all of the text books on nervous diseases.

On looking up the literature, however, I am unable to find any cases reported in which x-ray examination revealed the condition as shown here, except a case reported by Pancoast in The American Journal of Roentgenology, March, 1918, which may be of the same type. He merely says, in regard to the case, that the girl was referred for supposed esophageal stricture, but the obstruction in the esophagus was neurotic in origin.

Fig. 2. Case 2. Plate made before meal showing dilated stomach and esophagus in right mediastinum.

Fig. 3. Case 3. Right lateral view showing stomach and esophagus with penetrating ulcer on lesser curvature of stomach just above incisura.

Case II. Referred by Dr. E. P. Porter, for examination of the stomach and duodenum, January 30, 1920.

History.—Male, age fifty-eight; occupation, salesman.

Previous History.—Negative, except for ordinary diseases of childhood. For the past twenty years or more the patient has had more or less digestive disturbances. These consisted of some difficulty in swallowing, in that he had to eat or drink slowly because of some distress in the mediastinum whenever he tried to eat or drink rapidly. He complains of soreness in the right hypochondrium, most marked soon after eating; also some gnawing sensation in the chest, behind the heart. These are relieved by belching of gas after taking alkalies. Occasionally, during the past few years he has had to bring on vomiting by tickling the pharynx to get relief. Of late the symptoms have been more constant and recently, having had a bronchitis, he noticed a tendency to regurgitation when he coughed, especially when lying down. He has never noticed blood in the vomitus, which usually contained food taken several hours previously. His weight was constant up to one year ago, but in the past year he has lost about ten pounds. The bowels are constipated. No history of acute abdominal or chest symptoms and no history of injury to the thorax or abdomen.

On screen examination, there was observed an abnormal shadow in the right chest, extending from the right clavicle to the diaphragm. The margin of this was smooth, except for an indentation opposite

the right second interspace. The left margin of this shadow was fused with that of the heart and vessels of the mediastinum. On rotating the patient, it was observed that this abnormal shadow was in the posterior mediastinum. The barium meal was observed to enter the upper portion of this shadow region and was delayed here for two or three seconds and then continued on into the lower part of the shadow, none of it passing below the diaphragm. Meanwhile, a considerable portion of the meal connected in the upper sac.

Plates were now made in various positions, such as standing direct, oblique and lateral; prone direct, oblique and lateral. An attempt was made to examine the patient on an inclined plane with the head lower than the feet, but he could not retain the meal in this position. Plates were made six hours after the meal, twenty-four hours afterward and forty-eight hours afterward. Stereoscopic plates of the chest were also made on one of these later visits when the chest contained no barium. Stereoscopic plates were also made in most of the positions above enumerated with a barium meal in the chest.

The plates made without barium in the chest show that this abnormal shadow in the mediastinum is not very dense, as the bronchial tree on the right side may be seen through this shadow. Stereoscopically, it is seen to be tubular and apparently contains air in the lower two-thirds, there being less marked distention above. In the plates made directly with the patient prone, most of the barium is seen in the lower mediastinum, behind the heart shadow. There is some barium also in the upper sac. In this position, the lower shadow assumes the shape of the stomach. In the right lateral position, with the patient lying on his right side, the lower sac seems to be the stomach; and the pylorus and antrum are visible, as well as the greater and lesser curvatures. All of the plates made in this position show a projection from about the middle of the lesser curvature suggesting a penetrating ulcer or adhesion here. The lower sac shows several indentations on both

Fig. 4. Case 2. Six hour plate. Only small amount of barium in intestine.

Fig. 5. Case 2. Twenty-four hour plate. Stomach empty, most of meal being in colon.

sides, evidently peristaltic waves. The upper sac also shows sharp bilateral indentations suggestive of the haustral markings of the colon. In the plates made with the patient standing, little of the barium remains in the upper sac. The six-hour plate shows most of the meal still in the chest, a small stream being visible in the small intestine below the diaphragm. The twenty-four hour plate shows most of the barium distributed throughout the colon, with a small amount remaining in the terminal ileum. The patient's bowels moved spontaneously at thirty hours, so that later plates showed only traces of the meal in the colon.

From the above findings, I believe that the shadow in the right mediastinum is due to the presence here of the stomach and dilated esophagus above it. There is very little of the small intestine above the diaphragm. The dilatation and hypertrophy of the esophagus are due to constriction of the cardiac end of the stomach. The stomach empties some time between six and twenty-four hours (unable to get intermediate plates). The defective motility of the stomach is due to constriction of the small intestine, at the opening in the diaphragm, and spasm of the pylorus as a result of the lesion on the lesser curvature.

The small intestine is practically empty at the end of twenty-four hours. The condition now present has probably existed for many years. There is no history of trauma and no history of acute abdominal crisis. For this reason, it would seem that the stomach probably passed through one of the normal openings in the diaphragm, most probably the esophageal and that the esophagus was carried up into the chest with the stomach.

Hernia of the stomach and other abdominal viscera through the diaphragm was, until recent years, considered quite rare. However, since the advent of *x*-ray examination of the hollow viscera, the number of cases reported has markedly increased. Particularly is this true since the recent war. Necessarily, there were many wounds of the diaphragm, and as a result of these there have been many cases reported of hernia through these wounds, and some of these cases were not recognized until the patients had been through several hospitals. The cases difficult of diagnosis, even with *x*-ray examination, are those in which the opening in the diaphragm is small and a part only of the stomach or intestine is involved. Soresi has recently reported such cases.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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ANNUAL MEETING EASTERN SECTION

The Second Annual Meeting of the Eastern Section of the American Roentgen Ray Society will be held in Atlantic City at Haddon Hall-Chalfonte, on Friday evening and Saturday, Jan. 28, 29, 1921. Make hotel reservations early, mentioning American Roentgen Ray Society.

Communications regarding the program should be addressed to Dr. David R. Bowen, 82 West LaCrosse Ave., Lansdowne, Pennsylvania.

In all other matters concerning this meeting address Dr. Joseph M. Steiner, 103 Park Ave., New York City.

ANNUAL MEETING CENTRAL SECTION

The Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY will be held on February 21, 1921, at St. Louis, Missouri. Announcement of headquarters will be made later.

Communications regarding the program should be addressed to the president, Dr. James G. Van Zwaluwenburg, Ann Arbor, Michigan. The chairman of the local committee, Dr. Edwin C. Ernst, 412 Humbolt Building, St. Louis, may be addressed concerning matters of arrangements.

THE CALDWELL LECTURE

THE AMERICAN ROENTGEN RAY SOCIETY has sought to honor some of its former members, martyrs to their profession. Two thus far honored are Leonard and Caldwell. At the last annual session, a Leonard prize was voted, details of which will be found elsewhere in this number. Eugene W. Caldwell's work placed him in the foremost rank of American medical scientists, and it is highly fitting that each year the memory of our beloved co-worker shall be freshened by a lecture given in his name. It is planned to have an hour set apart on each annual program for a formal lecture on some topic relating to roentgenology or radiumtherapy, the speaker to be chosen by the president each year. For the first Caldwell lecture at Minneapolis, Minnesota, Thursday afternoon, September 16, 1920, we had the honor and the privilege of hearing Dr. Walter C. Alvarez, Assistant Professor of Research Medicine, George Williams Hooper Foundation for Medical Research, University of California Medical School, San Francisco, California, on "Peristalsis in Health and Disease," whose paper appears in this number. JAMES T. CASE.

COMMUNICATIONS

PARIS LETTER

DURING the course of the war a large number of French and American radiologists had occasion to meet and to work together in the various medical organizations at the front and in the interior. Thus were established those sympathetic and friendly personal relations which make it more desirable than ever that they keep in touch with each other and that they reciprocate in their labors and their researches. Constantly informed by his faithful and eminent friends of the remarkable development of radiology in the United States, and endeavoring to pass on to those about him all that he thus learns, the author of these lines has long hoped that his colleagues in the United States might come to take an equal interest in French radiology.

He therefore accepted joyfully, in spite of very numerous duties, the proposition transmitted through Dr. Béclère, Master and Dean of French radiology, to write for the readers of THE AMERICAN JOURNAL OF ROENTGENOLOGY a monthly letter from Paris portraying as faithfully as possible our radiologic activities; and he takes this occasion to congratulate his colleagues, particularly Drs. Hickey and Imboden, on their initiative in creating this new department.

He will endeavor to present in these articles all that is new and interesting in France in the various domains of radiology and radium therapy, and at the same time he will seek to inform those in the United States who may have occasion to come to France as to the hospital services and the laboratories which they will find it most profitable to visit.

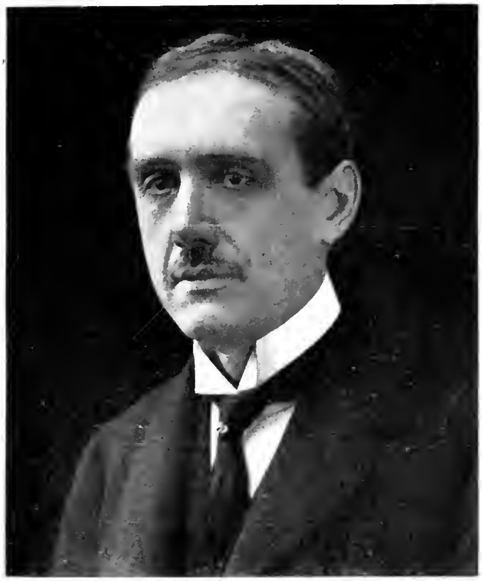

FIG. 1. DUC DE BROGLIE.

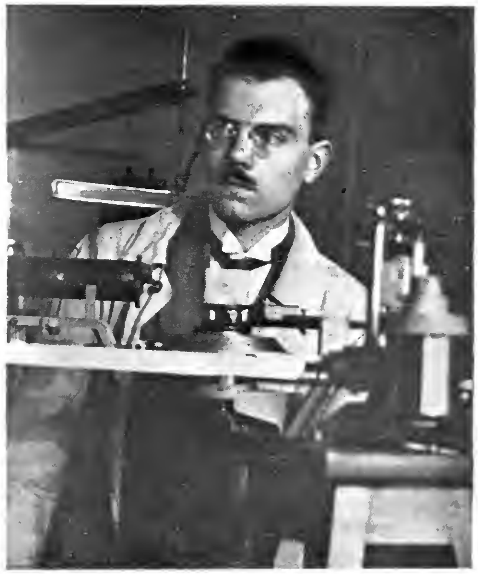

FIG. 2. DR. A. DAUVILLIER AT WORK IN THE LABORATORY.

Modern research tends to show that all progress which may be made in the application of the x-rays to medical diagnosis and treatment is inseparable from physical research, and that all productive work thus necessitates the active and continued collaboration of the physicist, the constructor and the radiologist—that is, the constant union of theory and practice.

One of the first to perceive clearly this necessity was the eminent physicist M. Villard, of the Academy of Science, to whom we owe the discovery of the gamma rays of radium, the invention of the osmo-regulator, and the appearance in 1908 of the first ap-

paratus for the measurement of the x-rays by ionization. We owe to Dr. Coolidge, together with the most important advance in radiologic technique since Roentgen's discovery, certain facilities for experimentation which profit medicine and physics equally, and which give a new impetus to the collaboration of these two sciences.

A number of French radiologists, therefore, have thought the moment well chosen for the establishment of a laboratory for research in the field of x-rays, and to facilitate the study of all questions which may directly or indirectly interest either physicians or technicians.

The Duc de Broglie, well known for his spectroscopic studies of the x-rays, and who has at present for his personal use a well-equipped laboratory, has generously offered, to shelter the new organization, an entire building completely furnished and equipped with the most excellent and modern apparatus. Except for the very modest assistance of the writer, the Duc de Broglie oversees entirely the functioning and maintenance of the laboratory, and assumes the scientific direction of it.

Dr. M. A. Dauvillier, a young physician of great future, already known by his interesting work with the x-rays, is attached to the laboratory. Some of the readers of this letter will perhaps remember having seen him during the war in the x-ray department of the Descartes hospital at Tours, where we first realized the value of an intimate relation between a physical laboratory and a medico-surgical x-ray service. For, modest as it was, that laboratory where so often Colonel Shearer lavished upon us the precious counsel born of his long experience, was the scene of some research work which the Academy of Science viewed with interest, and the continuation of which it encouraged with an important prize.

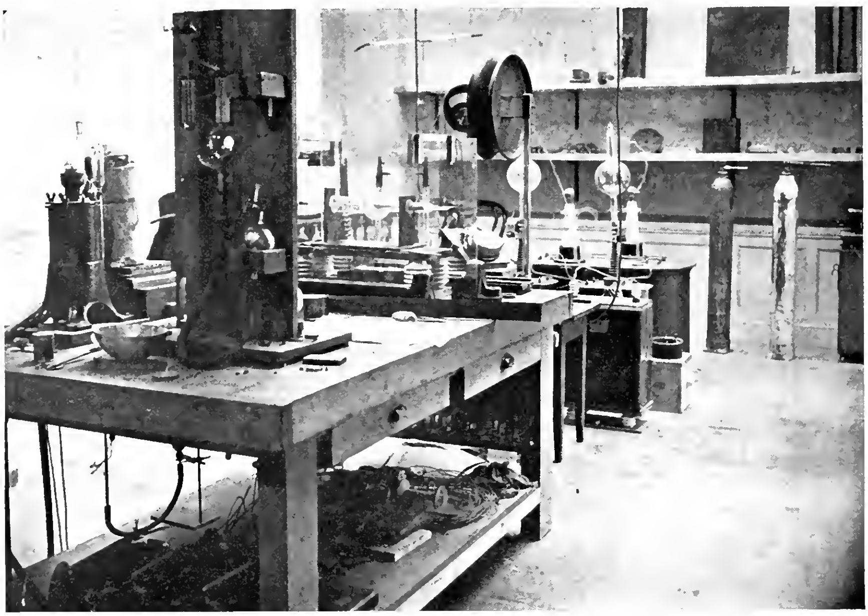

Fig. 3. View of Research Room in the Laboratory, Showing in the Background High-tension Transformer with Kenotrons and Condensators for Continuous High-tension Work. A quartz tube and the Abraham-Villard voltmeter are visible in the center, whilst the vacuum pump shows in the foreground.

We may hope, therefore, that under the direction of the Duc de Broglie, and profiting by his large experience, the laboratory will not delay in giving proof of its utility.

To describe it briefly, it is housed in a building having a basement and two stories.

In the basement are a preliminary vacuum apparatus (a motor and a pump working in oil), and a converter for changing 110 V. D.C. into 250 V. single phase alternating current of 600 periods (60 cycles). This group has a capacity of 5 K.V. A.C. The ground floor includes an office, a dark room, and two laboratories. The smaller laboratory is at present reserved for the study of Lilienfeld apparatus. The larger one contains (a) a coil with mercury interrupter working on the 110 V. D.C., and (b) a Gallot-Gaiffe transformer working on the 120 V. single phase alternating current, and which can supply the incandescent cathode type tubes with a maximum of 170 K.V. controlled by an auto-transformer. Voltages are measured by an Abraham-Villard electro-static voltmeter. This laboratory has also facilities for pumping vacuum tubes, namely, a special quartz condensation pump, with a Gaede rotary pump for preliminary pumping, permitting the obtaining of very high vacuums with considerable speed; and a Pilon apparatus.

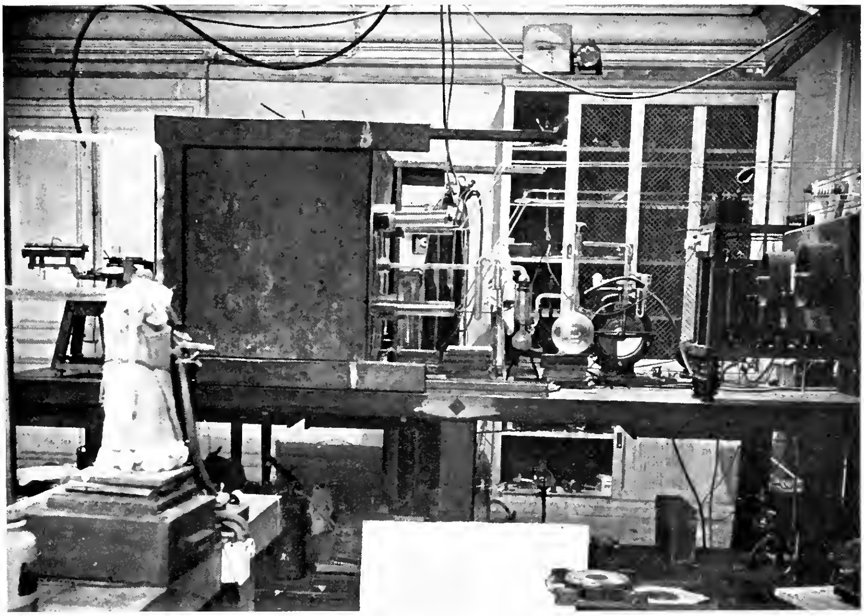

Fig. 4. Another Part of Research Room, showing the quartz vacuum pump and Gaede pump on the right, the large lead box (weighing over a ton) in the center, and the spectrometers on the left.

The spectroscopic apparatus in use includes a Bragg spectrometer and a Broglie spectrograph. These permit the simultaneous analysis of rays from two sources enclosed in lead boxes of about one cubic centimeter capacity, and having a wall thickness of 15 mm. Two other pieces of spectroscopic apparatus, including a monochromateur, and a spectrograph of special precision for the study of very short wave lengths, are under construction.

The experimental tubes used are almost exclusively constructed of quartz.

The researches undertaken by the laboratory are not confined to purely theoretical physics. An important place is reserved for all questions of interest from the medical viewpoint, and particularly for radiotherapy, which is closely connected with the study of rays of very short wave length.

Finally, the laboratory, endowed with a very complete library, may be regarded (although not public) as a center where workers lacking information on certain points of physics of radiology may bring their problems, and continue their researches.

If the readers of this first letter reproach

us with having dealt exclusively with physics, we hope that Dr. Coolidge, who manifested his interest in the new creation when he visited it last August while it was under construction, and who considered it to be the only institution of its kind in the world, will deign to say a few words in our defense. He will agree with us perhaps that the future of radiology, and particularly of deep radiotherapy—a domain as vast as it is interesting—depends entirely upon the close collaboration of the physician and the physicist.

The description we have given will serve as an introduction to the letters which will follow, and if it has seemed wearisome to some of our American colleagues because we have not spoken of medical radiology, we hope they will pardon us, and we promise them that we will not stray into the domain of physics again for a long time.

Dr. R. Ledoux-Lebard.

BOOK REVIEWS

The Story of the American Red Cross in Italy. By Charles M. Bakewell. Pages 225. Illust. Price, $2.00. Macmillan Co., 1920.

This most attractive volume is a faithful history of the accomplishment of the American Red Cross in Italy beginning with May, 1915, the date of Italy's entrance into the war, and continuing the narrative until up to the middle of 1919, when Red Cross war activities were practically closed in Italy. The book tells not only of the establishment of relief centers, work-houses, traveling canteens, "asili" for children and large hospitals, but also of the building of entire cities for the accommodation of refugees from the Piave and from Venice. It is highly fitting that the accomplishments of the American Red Cross should be thus chronicled. We hope there will be a wide distribution of this work.

James T. Case.

TRANSLATIONS & ABSTRACTS

Lovett, Robert W., and Wolbach, S. B. Roentgenographic Appearance, Diagnosis, and Pathology of Some Obscure Cases of Bone Lesions. (*Surg., Gynec. and Obst.*, Vol. xxxi, No. 2, August, 1920.)

For the past five years the writers have been concerned in a conjoined study of certain obscure bone lesions, occurring in the orthopedic service of the Children's Hospital. In cases where the diagnosis of a bone lesion was in doubt, the pathologist has been present when operations were to be performed, and has taken his own specimen when the bone was opened, so that if possible an immediate diagnosis could be made by frozen section, and the operative wound treated accordingly. When the pathologist could not make a diagnosis in this way, the specimen was taken to the laboratory, studied, and reported on later. The cases presented are those in which there was, in the minds of the writers, doubt as to the correct diagnosis from the *x*-ray and other data available before operation. Each case is presented with a short clinical history, an *x*-ray and a pathological report. The writers are indebted to Percy Brown, radiologist of the Children's Hospital, for co-operation in the study, and to John J. Morton, of Boston, also a hospital associate, for much labor in the collection and arrangement of the data. Considering the behavior of bone in general, as studied by the *x*-ray, it seems to be a structure of very limited reaction to pathological conditions. Regarded from this point of view, there seem to be only three reactions possible in bone. These are: (1) atrophy or diminution in line content; (2) destruction of bone tissue, local or general; (3) a formative process, characterized by formation of new bone, or a condensation of existing bone around a focus of disease. The general point of view with regard to these processes has been that tuberculosis is largely destructive in character; that the tuberculosis is characterized by marked atrophy of the affected bone, with perhaps atrophy of contiguous bones in the same limb; and that it occurs in the region of the epiphysis. Osteomyelitis has been generally regarded as a process at first destructive in character, and then formative, the formative process generally becoming dominant. Syphilis has been considered as the most purely formative of the three processes, with some element of destruction, but much more formative than either of the others mentioned. When the writers attempted to study, from the point of view of pathological findings, *x*-rays taken of cases prior to operation, it became evident that this criterion could not be depended upon; that tuberculosis, which has ordinarily been spoken of as occurring in the articular ends of bones, might occur in the shaft, and that it might be almost a purely formative process, or that the formative process might exist with the destructive process, and ultimately become dominant; and that a local destructive process, indistinguishable from the so-called Brodie's abscess, might occur in a pure tuberculosis, so that a localized cavity in bone, well walled off, might occur in this disease. It appeared also that a wedge-shaped destruction in the articular end of the bone, with the base of the wedge toward the joint, might occur both in tuberculosis and osteomyelitis, and that under these circumstances the two were practically indistinguishable. The errors in diagnosis, in the experience of the writers, have more often consisted in mistaking tuberculosis for other things than in mistaking other things for tuberculosis. A curious punched out lesion of the skull was identified pathologically in two cases as being definitely tuberculosis. The other confusion which was most troublesome arose between osteomyelitis and spyhilis, two cases involving the lower end of the fibula being shown which were in *x*-ray appearances practically identical. Again, the stage of repair in osteomyelitis may be seen in the *x*-ray of two tibiae to be very similar in spyhilis and osteomyelitis. As it has appeared to the writers, the problem of differentiating the three conditions mentioned by means of the *x*-ray, is not encountered, as a rule, in the routine case in which a purely destructive lesion is most often tuberculosis. The lesion of rapid destruction, with marked formative activity, is generally osteomyelitis, and the purely formative process is most likely to be syphilis. The serious problem of differential diagnosis occurs most often in cases in which focal lesions are present, in which the phenomena of formative and destructive ac-

tivity have become so mixed that without the pathological examination, in many of them the diagnosis is impossible. The advantage of such a diagnosis made during the operation is evident to any surgeon, because it guides him in the treatment of the bone cavity, and is often the direct factor in deciding whether or not to close such a cavity. In addition to the three conditions of tuberculosis, osteomyelitis, and syphilis, certain other bone lesions are shown, which have a bearing on the question of diagnosis. A short summary of the case histories will be presented, the salient pathological facts discussed, and conclusions drawn as warranted.

DISCUSSION

The diagnosis of infectious lesions of the bones would be simple if each infectious agent always produced the same reaction. The pyogenic bacteria alone may be counted upon to conform to type; at first destruction of tissue followed by repair, which in the case of bone means necrosis with more or less local disappearance of lime salts, followed by new bone formation from adjacent healthy bone structures. It must be remembered in the reaction of bone to injury that new formation of tissue is always followed by ossification and therefore that granulation tissue from bone or periosteum becomes bone tissue. The above simple sequence in the pyogenic infections accounts for the definite criteria applicable in osteomyelitis. It is conceivable that a rapid healing of a small abscess in bone might result in very little granulation tissue production from adjacent tissue with very little production of new bone. Syphilis affects the bone in two ways, both effects of the proliferative reaction of the casual agent, and results either in the destruction of bone, or the new formation of bone. Both effects may occur in the same case. Destruction of bone follows the formation of local, rapidly-formed gummatous lesions, sometimes of endosteal and periosteal origin, sometimes perivascular and extending into bone. On the other hand, the degree of reaction to the spirocheta may be slight and result only in proliferation of cells of the periosteum and endosteum, the newly-formed tissue developing osteoblasts and eventually new deposit of bone is the result. In one case, therefore, there is choking of normal bone by the gummatous process with its necrosis; in the other case there is merely stimulation of bone-forming tissue. Tuberculosis presents more possibilities. In soft tissues it is known that the tubercle bacillus can duplicate the reaction of almost any type of pathogenic bacterium. Thus the various types of exudative response to injury may be the result of the tubercle bacillus alone; exudates essentially fibrinous or essentially puriform in character are frequently found upon serous membranes—meninges, peritoneum, pleura, and pericardium. In bone we usually think of tuberculosis as a proliferative process resulting in the new formation of tissue with consequent obstruction of the bone, and this is the commonest type of tuberculous bone lesion which gives rise to the formation of bone cavities without a peripheral reaction or condensation of bone.

In tuberculosis of bone, as in soft tissues, there may occur: (1) Exudate, fibrinous or puriform, (2) discrete proliferative lesions, the tubercle which may progress slowly or rapidly with much or little caseation, and (3) a diffuse proliferative reaction, following the exudative—essentially tuberculous granulation tissue, with much or little caseation. In the third instance, in the granulation tissue, there may be new bone formation just as in the repair of pyogenic processes, at a time when destruction or resorption of bone is going on.

The important lesson from the pathological study of this series of cases is the reminder that tuberculosis in bone may simulate any other infectious process in location and character of the lesion. Diagnosis from *x*-ray studies alone is therefore occasionally impossible and recourse must be had to other clinical evidence, and when possible to pathological examination.

CARMAN, R. D., Mayo Clinic. The Roentgen Diagnosis and Localization of Peptic Ulcer. (*Calif. State J. of Med.*, November, 1920, Vol. xviii, No. 11.)

Many roentgenologists refuse to make a diagnosis in the absence of direct signs, and claim that complexes made up of indirect signs are of no value. This view is far too radical, for if roentgen ray diagnoses were limited to cases in which direct signs only are noted, many lesions of the alimentary canal would pass undiscovered. Often more remote phenomena must be considered in the diagnosis, such as alterations of motility, tonus and peris-

talsis. All of these manifestations are affected by spasm. For instance, we are more or less dependent on changes of contour, spastic in nature but set up by an intrinsic lesion, such as spasmodic hour-glass of gastric ulcer or the spastic deformity of duodenal ulcer. We must also be able to recognize the spastic deformity produced by extrinsic lesions remote from the deformed organ. Such deformity may simulate that produced either directly or indirectly by an intrinsic lesion. Thus two types of spasm are met with; one may be spoken of as intrinsic, the other as extrinsic. The first is often a help in diagnosis, the latter often a hindrance.

He mentions that four types of gastric ulcers may be distinguished at operation.

1. Small mucous erosions and minute, slit-like ulcers.

2. Penetrating, or perforating ulcers with relatively deep craters.

3. Perforated ulcers, with or without the production of accessory pockets.

4. Carcinomatous ulcers.

The first type of ulcer, the small mucous erosion, offers the greatest difficulty to roentgenologic detection. It is either a superficial denudation, or a mere slit in the mucosa incapable of holding enough barium to make a visible projection from the gastric lumen.

The penetrating or perforating ulcer which has burrowed more or less deeply into the gastric wall, but does not penetrate the peritoneal coat of the stomach, produces a definite crater jutting from the lumen of the stomach. The degree of facility with which this crater can be seen by the roentgen ray depends more on the location than on the size of the crater.

The perforated ulcer which has excavated through the peritoneal coat of the stomach may, at the time of perforation, become covered by gastrohepatic omentum, or, if the perforation is chronic, it may be protected by adhesions. In either case the roentgenologic signs are the same as in the penetrating or perforating ulcer before perforation takes place. The only condition indicating perforation, therefore, is the depth of the crater. Perforation of an ulcer with a continuation of the destructive process into adjacent tissue results in the formation of an accessory pocket outside the stomach.

Carcinomatous ulcers are not, as a rule, distinguishable from non-malignant ulcers; their roentgenologic signs are very much the same as those of penetrating and perforated ulcer.

The roentgen ray signs of gastric ulcer may be divided into three groups.

1. Direct signs (pathognomonic).
   a. The niche.
   b. The accessory pocket.
2. Indirect signs (but diagnostic).
   a. Organic hour-glass stomach.
   b. Spastic manifestations.
      1. Spasmodic hour-glass stomach.
      2. Gastrospasm.
3. Corroborative signs (not diagnostic).
   a. Retention from the six-hour meal.
   b. Gastric hypotonus.
   c. Alterations of peristalsis.

Ulcers not sufficiently extensive to produce an excavation that can be visualized on the screen or plate are rarely found at operation; they are mere mucous erosions or small crevices, and their diagnosis can be made only on less definite signs such as spasmodic hour-glass stomach.

Indirect signs (but diagnostic).

1. Organic hour-glass stomach.
2. Spastic manifestations.
   a. Spasmodic hour-glass stomach.
   b. Gastrospasm.

It has been his experience that an hour-glass that resists belladonna to the physiologic effect means a lesion either of the stomach or duodenum; and regardless of whether or not the hour-glass is present at operation, the surgeon will find the cause, if he looks for it.

Corrobation signs (not diagnostic).

1. Retention from the six-hour meal.
2. Gastric hypotonus.
3. Alterations of peristalsis.

Six-hour retention—A distinct residue in the stomach from the six-hour meal is seen in 55 per cent of the gastric ulcer cases. In this respect gastric ulcer stands a close second to gastric cancer. The manner in which an ulcer causes retention is not definitely known in many cases. While it is easy to understand how an ulcer located at the pyloric ring may cause obstruction, it is hard to understand why one situated remote from the pylorus should do so. But practically 90 per cent of all gastric ulcers occur in the vertical portion of the stomach above the incisura angularis. The retentions which they produce have been assigned respectively to pylorospasm excited by the ul-

cer, to impairment of peristalsis, and to hypotonus. A retention alone is not sufficient evidence for the diagnosis of ulcer, since various causes may operate to produce a six-hour residue.

Gastric hypotonus—An evident loss of tone shown by sagging and expansion of the lower gastric pole is a frequent accompaniment of ulcer, not only of ulcers causing obstruction but also of those situated rather remote from the pylorus. Hypotonus alone possesses little significance, for it is an expected finding in the numerous patients of anteroptotic build; but if the hypotonus does not accord with the habitus of the patient, the possibility of an ulcer should be considered.

Abnormalities of peristalsis.—The variations of peristalsis met with in gastric ulcer include weak peristalsis, hyperperistalsis, especially of irregular type, absence of peristalsis, especially of irregular type, absence of peristalsis from the ulcer-bearing area, and anti-peristalsis. None of these is peculiar to ulcer, but all of them are more or less suggestive of a gastric lesion. All lesions of the gastric wall tend to interfere with peristaltic movement in the area involved. If an ulcer is located at a point where peristalsis commonly is visible a noticeable absence appears in the ulcer area. Anti-peristalsis is occasionally noted with gastric ulcer, and while it is not necessarily indicative of ulcer, it generally denotes the existence of organic disease either in the stomach or duodenum, with or without obstruction.

Carcinomatous ulcer.—The roentgenologic signs of ulcer differ so much from those of carcinoma in the larger number of cases that differentiation requires no effort. A callous ulcer with a niche, or a perforated ulcer with pocket formation, has no roentgenologic resemblance whatever to a well-developed carcinoma. Usually ulcers project from the gastric contour, while in carcinoma the growth with its resultant irregularity extends into the gastric lumen. Between the typical ulcer and the typical carcinoma there is a small percentage of cases in which the roentgenologic differentiation is impossible.

DUODENAL ULCER

He states that the roentgenoligic indications of duodenal ulcer may be classified as follows:

1. Direct signs.
   a. Deformity of the duodenal bulb.
   b. Duodenal diverticulum.
2. Indirect signs (diagnostic).
   a. Gastric hyperperistalsis.
   b. Gastric retention from the six-hour meal (the combination of hyperperistalsis with gastric retention and a normal gastric outline is diagnostic of duodenal ulcer with obstruction.)

He enumerates deformities more or less characteristic of duodenal ulcer as follows:

1. General distortion with the entire contour of the bulb deformed. This distortion is largely due to spasm, which is practically always persistent and unvarying.

2. The niche type in which the excavation of the ulcer is seen projecting from the bulb. This type is rare.

3. The incisura type of deformity, either single or bilateral. The incisura occurs in the plane of the ulcer, and may be the sole abnormality of contour observed. Unusually narrow but of variable depth, persistent and permanent as to situation.

4. The diminutive bulb. This is represented by a small, compact mass of barium in the cap. It is usually produced by an ulcer stenosing the duodenum, so that only the proximal portion of the bulb is filled.

5. The accessory pocket. This results from a perforated ulcer which has invaded tissue outside the duodenum.

6. The diverticulum. A diverticulum in the first part of the duodenum is relatively uncommon. It is found near the pylorus, and its relationship with duodenal ulcer and scars seems well established.

Cases without ulcer are seen in which the bulb fails to show a normal contour simply because of incomplete filling. This is likely to happen in cases in which the duodenum is large, but the deception is evidenced by the varying aspect of the deformity.

In an overwhelming preponderance of cases a constant deformity means duodenal ulcer. Such deformity is not absolutely diagnostic, since distortion of the duodenal shadow may result, though rarely, from an adhesion-producing process in the right upper abdominal quadrant, or possibly from reflex spasm set up by lesions outside the duodenum.

Indirect signs. Hyperperistalsis. Hyperperistalsis consists of three or more waves running along the stomach at one time. It is seen in a large proportion of cases and is most exaggerated in the obstructive cases, but it occurs also when there is no obstruction. A characteristic feature is the regular succession and symmetrical correspondence of the waves on both curvatures. A mere exaggeration of wave depth should not be confounded with hyperperistalsis, since an essential feature of the latter is an increase in the number of waves, although they may also show unusual vigor. Hyperperistalsis is often intermittent in character, periods of activity alternating with periods of rest. Of course the phenomenon of hyperperistalsis is not limited to duodenal ulcer, for it may accompany disease of the gall bladder or appendix or be seen normally in the hypertonic stomach. Obstructing pyloric and prepyloric lesions are sometimes attended by hyperperistalsis, but in such cases the waves are rarely uniform in depth and sequence, and they are chiefly on the greater curvature. Occasionally, however, this variety of peristaltic exaggeration accompanies a perforated duodenal ulcer.

A logical result of hypertonus and hyperistalsis is hypermotility, provided no marked obstruction has been produced by the ulcer. Generally speaking, the initial clearance in cases of duodenal ulcer may vary from a slight increase to a profuse flow or it may be abnormally scant with obstruction, and the moderate intermittent outflow of normal conditions may be absent. Hypermotility is not peculiar to duodenal ulcer, for it is a common effect of gastric cancer, achylia, and the diarrheas. On the other hand, about 25 per cent of the duodenal ulcers are sufficiently obstructive to produce a six-hour retention in the stomach. If in addition to the gastric retention there is a typical gastric hyperperistalsis, the diagnosis of a duodenal ulcer by *x*-ray is quite as certain as a diagnosis on any other evidence that can be obtained.

Clagett, A. V. The Treatment of Goiter with Radium. (*Illinois M. J.*, xxxviii, No. 4, p. 318., October, 1920.)

In the author's opinion, the toxic and Graves' disease forms plus the malignant and parenchymatous types are the only varieties where radium would be beneficial, though experimental work may show it applicable to a few of the other forms.

He has treated to date 47 cases of exophthalmic goiter with radium, the patients' ages ranging from 16 to 74 years. Of these cases six had already been operated on with recurrence of symptoms as bad or worse than before. Seventeen cases were declined as operable risks. Eight cases had to be rayed the second time as the dosage was inadequate and while the patients improved, the first raying did not give satisfactory results. Two cases with very bad broken compensation of the heart have died since treatment from acute dilatation, one three months after treatment, the other five and one-half months, though in both these cases the pulse had showed an average reduction of thirty beats and the nervous symptoms were remarkably reduced. In one case out of five there has been no reduction of the goiter. The circumference of the neck has diminished from 1¾ of an inch to 3¼ inches in the others. One woman's goiter did not decrease until thirteen months had elapsed and then suddenly went down 1⅝ inches in less than two months.

The exophthalmos has been usually the last symptom to disappear and has remained in five of the cases. The pulse beat has been reduced twenty to fifty beats. Nervous symptoms and tremors have disappeared entirely and the patients gained in weight and general well being. There has been symptomatic cure in all of the cases treated with the exceptions noted.

The author believes radium should be given a trial in exophthalmic goiter. Surgery had not been necessary in a single one of the forty-seven cases, some of them extending back nearly three years.

Spencer, Hunter B. Roentgen Therapy. (*Charlotte M. J.*, Vol. lxxxi, No. 6, p. 225, June, 1920.)

The results to be obtained in roentgen therapy are in large measure dependent upon a careful application of the following principles:

1. Correct diagnosis and knowledge of the existing pathologic process.

2. Proper selection of cases and recognition by the roentgenologist of the scope and limitations of this agent.

3. Knowledge and experience necessary for the proper administration.

4. Co-operation of the patient and the family physician referring the case.

Indications for treatment by the roentgen ray are—well advanced anemia, organic heart disease, diabetes mellitus, chronic nephritis, lung disease and goiter with heart symptoms, all patients beyond forty in whom there is no contra-indication. Young women in whom it would be necessary to do a hysterectomy in order to remove the growth.

Contra-Indications.—Where there are small pedunculated tumors, in young women healthy otherwise, which can be excised without destroying the reproductive powers of the patient. When tumors are complicated by malignant degeneration or are beginning to become necrotic. When associated with disease of the adnexa, or when the patient's condition is such that the danger of an operation is less than that of a delay of six or eight weeks which would be necessary to obtain results.

The experience of the writer and that of other roentgenologists would suggest the following conclusions:

Deep roentgen therapy stops the hemorrhage caused by uterine fibroids which is followed by a gradual disappearance of the tumor.

The treatment of metropathic hemorrhage is practically always successful.

Uterine hemorrhage occurring at or near menopause, when not due to malignancy, will usually disappear quickly.

Roentgen therapy is a most valuable aid to the gynecologist.

Rinehart, D. A. Evidence of Gastrointestinal Disease as Revealed by Roentgenological Examination of the Digestive Tract. (*J. Arkansas Med. Soc.*, Vol. xvii, No. 5, p. 107, October, 1920.)

Roentgenological examination as a means of diagnosing diseases of the gastrointestinal tract has a distinct field of usefulness. There is no other procedure that permits as close and careful observation. It must be emphasized, however, that only those conditions which produce permanent change in the stomach or intestine can positively be detected by its use. Gastric and duodenal ulcer, and gastric cancer are the affections of the stomach most readily diagnosed by roentgenological examination. The reliability of the conclusions depends on the carefulness with which the examination is made.

Frequently the evidence will be sufficient for the roentgenologist to make a positive statement; again, the findings may be suggestive but not diagnostic. In the latter instance he can say that pathology exists at such a place or he can give his opinion of the cause of the trouble with the reasons for his belief. In this instance his diagnosis should be accepted as merely an expression of his opinion.

Marty, L. A. The Modern Treatment of Malignancies. (*J. Mo. M. Assn.*, Vol. xvii, No. 7, p. 271, July, 1920.)

In the year 1918 there were over 65,000 deaths in the United States from cancer. Put the life of a cancer patient at three years and you have a total of about 200,000 people suffering at all times from this disgusting and painful condition. Are we doing our best for these cases, or are we in a hopeless state of mind, feeling that there is no cure? The best treatment for this class of cases consists of thorough raying before operation, careful surgery, followed immediately by thorough raying, and this continued over several months.

Treatment by the ray is always in order, even in the completely hopeless cases, as much suffering is relieved, toxemia lessened, and the patient made more bearable to those about him.

Krupp, D. D. The *X*-Ray As an Essential Guide for Producing Artificial Pneumothorax in Advanced Cases of Pulmonary Tuberculosis. (*N. York M. J.*, October 30, 1920, p. 670.)

In advanced cases of pulmonary tuberculosis, the almost constant harassing cough and frequent hemorrhages are the most difficult symptoms to treat.

With the production of an artificial pneumothorax, the affected lung is collapsed and the annoying symptoms are more or less permanently relieved, certainly to a more marked extent than by the use of narcotics, and without their depressing effects. The purpose of the pneumothorax in these cases is not to produce a cure, primarily, but to render the patient's life more comfortable and possibly increase his chances for recovery.

In certain seemingly hopeless cases, the treatment has caused an apparent arrestment of the disease in three selected cases cited in this article. Two of the advanced cases became ambulatory, after the patients had been bedridden for almost a year. They have shown a great amount of improvement.

Before a pneumothorax is tried the x-ray stands out as the essential guide to the clinician. The fluoroscope is part of the guide. With the bedside unit, the hand fluoroscope is used to great advantage. The x-ray plates give the pathological findings as a permanent record, while the fluoroscope gives a clue as to the mobility of the chest and the excursion of the diaphragm of the affected side.

The following points were studied before pneumothorax was produced: (1) The extent of the pathology, especially as to cavities. (2) Will the opposite lung be able to furnish sufficient pulmonary tissue after the affected lung has been collapsed in front throwing additional risk to the patient? (3) Pleurisy and adhesions.

CURTIS, ARTHUR H. Radium Treatment in Gynecology. (*Wisconsin M. J.*, Vol. xix, No. 4, p. 172, September, 1920.)

The author has used radium for a period of five years. Each year there has been a relative decrease in the percentage of major operations, with a corresponding increase in the proportion of radium cases.

In the cases of uterine carcinoma very few cures have been obtained. This is ascribed to the fact that until very recently only those with bad prognosis have been reserved for exclusive radium treatment, and then, post-operative radium therapy has not been pushed to the limit. In spite of these unfavorable statistics, experience supplies an ever increasing evidence that radium is the best palliative remedy at our disposal in the management of uterine cancer and may entirely supplant radical operation in the treatment of this disease.

Except in very few instances of 62 fibroid cases no attempt has been made to avoid bringing on the menopause. Treatment has consisted in curettage, with intrauterine application of 50 milligrams for a period of 20 to 24 hours.

Radium makes possible a revival of treatment by myomectomy, favorable cases may have the larger tumors removed, and thereafter go through pregnancy with the assurance that radium will obviate the need of a second operation if other fibroids develop subsequently.

In 81 cases of the menopause hemorrhage was invariably controlled. The technique was essentially that used for uterine fibroids.

FISCHEL, E. The Use of Radium in Carcinoma of the Face, Jaws and Oral Cavity. (*J. Mo. M. Assn.*, Vol. xvii, No. 7, p. 267, July, 1920.)

In the author's experience, radium can be relied on to heal carcinomatous ulcers of the face. It is the most efficient method of treatment of carcinoma o fthe eyelids and has replaced operative treatment of carcinoma of the lower lip in a percentage of cases. Tributory glands should be removed by open operation.

The initial dose of radium should be the maximum one deemed necessary for the complete destruction of the carcinoma.

The persistent use of radiation after demonstrated failure of the growth to respond favorably is to be condemned.

Radium has limited use in carcinoma of the jaws and buccal cavity.

As an adjunct to surgery, radium is of great value, as its small bulk, diffuse and powerful action permit it to be implanted in small cavities otherwise inaccessible to any method of approach.

SCHMITZ, HENRY (Chicago). The Indications for Radium Therapy in Surgical Conditions of the Pelvic Organs. (*Wisconsin M. J.*, Vol. xix, No. 4, p. 157., September, 1920.)

The biological reaction of cancer cells to radiation offers the best evidence of the therapeutic and curative efficacy of the gamma rays of radium and the hard roentgen rays. The efficacy of the treatment must be based on the demonstrable reduction in the size of the tumor and not on the local changes and improvement in the subjective condition of the patient.

Considering that surgery can remove carcinoma tissue but not change the proliferative activity of the cancer cell and that radium and roentgen rays will arrest the active mitotic power of cancer cells but cannot remove them, it is obvious that in the treatment of cancer disease we must resort to the combined method of surgery and ray therapy provided the case

in question is a clearly operable one. In borderline and clearly inoperable primary and recurrent carcinomata we must confine the treatment solely to ray therapy.

The author reports the clinical results observed in 265 cases. Subtracting 21 clearly operable cases, there are left 244 that formerly would have been considered absolutely hopeless. Thirty-two of the 244 cases have survived a period of two or more years, during which time they enjoyed perfect health and working capacity. Eleven of these have succumbed and 21 are alive.

Giffin, C. E. Artificial Menopause Induced by the X-Ray. (*Colorado Med.*, Vol 17, No. 4, p. 84, April, 1920.)

This report is based on thirty consecutive cases selected for *x*-ray treatment between the year 1914 and 1920. Excessive menstrual flow constituted the chief indication for treatment in thirteen cases of this series. Many of them were cases of menorrhagia of the early menopause. Of these thirteen complete arrest of hemorrhage and complete suppression of menses were attained in each instance.

In five cases the reduction of definite fibroids was the chief indication for treatment.

Combined indications of menorrhagia and palpable fibroids were frequently encountered. There were six such cases in this group, making a total of eleven in which fibroids were a factor. Of these eleven, symptomatic cure was attained in each instance but three.

Recurrence of flow following primary discharge from treatment occurred in four instances.

Twenty-one of the thirty manifested before the completion of treatment more or less symptomatology suggestive of the menopause. In two of these cases the symptoms warranted the use of ovarian extract.

As to technique: The first dose is administered in halves with one week interval; beyond that the patient is given the full dose at one sitting and that is repeated every three weeks until one period is definitely missed. In the fibroid cases treatment is continued with a four weeks interval until the desired result is obtained. Only two areas are exposed, one anterior just above the pubes and the other posterior over the sacrum. The treatment cone is six inches in diameter and is provided with a three and one-half mm. aluminum filter with a wooden compression surface on the opposite end. A supplementary filter of one and one-half mm. is always added in treatment of this class of cases. The exposure time is sixteen minutes in the anterior and sixteen in the posterior position, with a spark gap of seven and a half inches with five ma. going through the tube. The skin-focus distance is always nine inches.

Age is the essential factor in determining the number of exposures required for menstrual suppression. Anatomical conformation is the other factor. When these are known it is surprising how accurately one can estimate the probable total time under treatment. Ages ranged from twenty-eight to fifty-four in this series. The fewest number of treatments given was three, in one of the cases close to the time for the natural menopause. The greatest number was thirteen, in one of the younger of the series. The average time under treatment was twenty-one weeks.

In conclusion the author emphasizes that careful history, examination and care in selection can define a large group of pelvic cases which are better treated by the *x*-ray than by any other means available. On the other hand, without the greatest of care, the *x*-ray may easily inflict upon the patient irreparable disaster.

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ROENTGENOGRAPHIC STUDIES OF BRONCHIECTASIS AND LUNG ABSCESS AFTER DIRECT INJECTION OF BISMUTH MIXTURE THROUGH THE BRONCHOSCOPE*

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AND

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NEW YORK CITY

DR. STEWART'S first experience in outlining the bronchial tree with bismuth mixture was purely accidental. In October, 1915, while fluoroscoping an old man with an esophageal obstruction, he observed some of the bismuth paste passing from the esophagus directly into the trachea through a fistulous opening, a portion of the paste passing down into the lower bronchi. A roentgenogram was immediately taken. The patient had three or four coughing spells, bringing up particles of bismuth paste, and the following day he seemed none the worse for his experience. The examination was repeated about a week later with no ill effects.

Upon investigation Dr. Stewart found that a number of similar cases had been reported. It occurred to him at that time that with proper precautions the injection of opaque substances into the lung through the bronchoscope could be safely undertaken.

It was evident that advancement along this line was slowly being made, for in 1917 Dr. Sidney Yankauer treated a case of bronchiectasis by direct applications of iodine solution to the diseased area through the bronchoscope. In conjunction with Dr. Willy Meyer and Doctor Yankauer, this patient was carefully watched roentgenographically. Complete recovery occurred.

Between 1915 and 1920 two cases of tracheo-esophageal fistula came under observation in which the main bronchial tree on both sides was outlined by bismuth paste escaping from the esophagus through a fistula into the trachea. Early in 1920, the same phenomena occurred in a case of carcinoma of the esophagus located just above the arch, complicated by laryngeal paralysis; also, in a patient suffering from carcinoma involving the laryngopharynx. In both these cases the bismuth paste entered the trachea beneath the epiglottis, which was imperfectly closed. Repeated roentgen examination of these two patients did not cause any ill effect.

During Dr. Stewart's army experience at Biltmore, N. C., while examining patients

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

suffering from chronic empyema, he frequently injected bismuth mixtures into an empyemic cavity which had direct communication through a pleuro-pulmonary fistula with a branch bronchus. The bismuth mixture would permeate many of the bronchial branches, be retained long enough to enable him to obtain satisfactory roentgenograms, and then would be expectorated. Such an occurrence, whether accidental or intentional, did not seem seriously to disturb the patient.

The experience mentioned above strengthened his belief that if accidental entrance could occur without danger, injections might be done deliberately and, when combined with roentgen examination, be used for diagnostic purposes.

Dr. C. Jackson, of Philadelphia, during 1918, reported a case before the American Laryngological Association, in which the main bronchi on the right side were outlined roentgenographically, after insufflating dry bismuth through the bronchoscope.

Drs. J. C. Bullowa and C. Gottlieb of New York, in 1919, reported some experimental studies on living animals in which the bronchi had been injected with bismuth and barium mixtures, roentgenographic observations of which brought out details of the bronchial tree heretofore never thought possible. They were able to demonstrate a "wave-like" peristaltic action in the bronchi and trachea.

So far as we are able to ascertain, it was not until early in 1920 that any successful efforts were made to outline roentgenographically lung cavities after the injection of opaque substances through the bronschscope. In May, 1920, Dr. Lynah, of New York, presented a short preliminary report on the subject before the American Laryngological Association; he reported two cases of lung abscess which had been successfully mapped out roentgenographically after the injection, bronchoscopically, of aqueous and oily mixtures of bismuth subcarbonate directly into the area of diseased lung; both these patients have since been repeatedly examined by the authors and are included in the five cases reported in this communication.

Case I. A man of twenty-six years who developed a lung abscess in July, 1919, after having aspirated sea-water while in swimming. He went out too far, became exhausted and went under; was hauled out and by first aid measures soon revived.

One week later he suffered from what was supposed to be bronchopneumonia; there

Fig. 1. Case 1. Lung Abscess One Month after First Injection. A. Abscess cavity faintly outlined. B. Remains of bismuth which infiltrated the lung structure at the time of the first injection.

was a great deal of foul expectoration at that time.

Within one month the acute symptoms had subsided, but he continued to expectorate large quantities of pus. He was sent to New Platz, N. Y., with a diagnosis of pulmonary tuberculosis even though no tubercle bacilli were found in the sputum. There he had several hemorrhages; the sputum showed numerous streptococci, he had fever and complained of having a "bubbling" sensation in his right chest. There were several night sweats. In February, 1920, the patient consulted Dr. F. W. Corwin of Newark, N. J., who referred him to Dr. Lynah for bronchoscopic examination.

Roentgenographic studies made by Dr. Corwin showed a definite shadow over the right lower lobe surrounded by a "pus soaked" area of infiltrated lung tissue. The diaphragm was attached and pulled upward. The roentgenologist in his report stated that there was a fluid level and gas bubble in an abscess cavity; this however Dr. Lynah was unable to make out. There was profuse expectoration of foul smelling pus, and the patient stated that he had coughed up as much as would fill two large preserve jars every twenty-four hours.

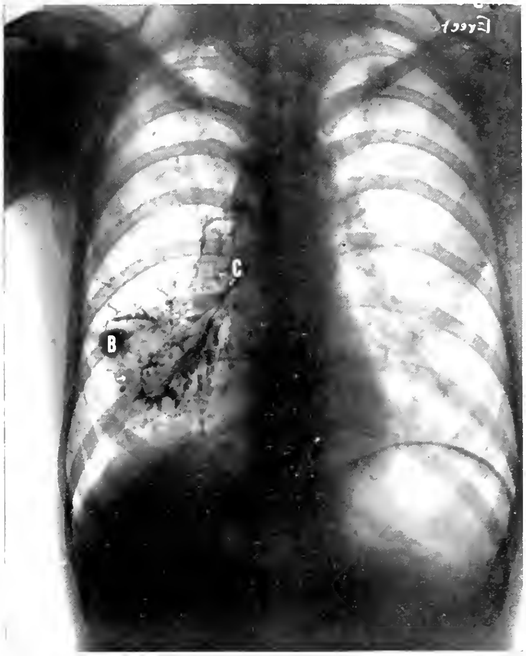


Fig. 2. Case 1. Lung Abscess. Immediately after Second Injection. A. Abscess cavity outlined with bismuth suspended in sweet oil. Small cavities and bronchial branches in involved area also outlined. B. Remains of bismuth infiltrated into lung structure from first injection. C. Main bronchial branches.

Fig. 3. Case 1. Lung Abscess Five Months after Injection. A. Area of diseased lung. B. Small amount of bismuth still remaining in lung structure from first injection.

He was bronchoscoped after further study of the roentgenograms. The bronchoscopist noted a profuse discharge of pus pouring out of the mouth of the bronchoscope. It was very foul smelling and blood-tinged. A 7 mm. bronchoscope was introduced so as to make it possible to study and explore the lower lobe branches. After thorough evacuation of the pus-filled bronchi, the superior lobe branch on the right side was examined and found, on coughing, to be free from pus. Pus was noted coming out of the right middle lobe branch, which was directly anterior, but, after this branch was sucked out, and the patient instructed to cough, no pus was in evidence. The lower lobe branches were filled with pus; this was removed by suction and each branch examined in turn and the patient instructed to cough; by this means the branch bronchus from which the pus was coming could be definitely located. The small, but constant ejection of pus with each cough, pointed toward the right anterior branch; this branch was sucked out; however, pus appeared in the mouth of the bronchus with each cough in spite of suction. The long slanting end of the bronchoscope was then insinuated into this branch. It was now noted that there were many granulations present which bled freely. About one ounce of bloody pus was aspirated at this time into a sterile bottle and examined by Dr. George S. Dixon of the New York Eye and Ear Infirmary,

who reported as follows: "The pus removed bronchoscopically from the lung abscess of Mr. F. H. shows a pure culture of Freelander bacillus." This was extremely interesting, for the most virulent cases which we see in the summer caused by swimming about New York harbor are usually due to the Freelander bacillus, one of the colon group. This man had a lung abscess caused by the inspiration of sea-water about New York harbor.

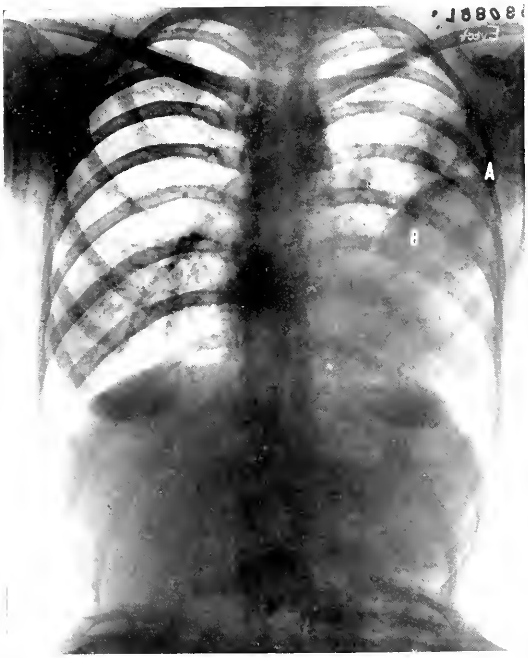


Fig. 4. Case 11. Lung Abscess Before Injection. A. Abscess cavity showing fluid level with air bubble above. B. Pus soaked in filtered area of lung structure surrounding the abscess.

For definite lung mapping the abscess cavity was injected the following week with a mixture of bismuth subcarbonate in olive oil (1–2). The right anterior branch was injected around a corner by a specially made curved spiral cannule; 8 c.c. of bismuth mixture was injected slowly so as not to infiltrate the surrounding lung tissue, and within five minutes from this time the patient was flurorscoped by Dr. Charles Gottlieb,, and some very interesting observations made. By fluoroscopy the cavities filled with the opaque mixture could be distinctly seen. Roentgenograms were also taken in all positions and a set of stereoscopic plates made. Within ten minutes the patient was again fluoroscoped and the bismuth mixture was seen coming out of the abscess cavity and flowing upward.

He had not coughed up to this time, for he was breathing as quietly as possible. He did have considerable cough, however, immediately after the removal of the bronchoscope, but the fluoroscopic studies made by Drs. Gottlieb, Corwin and Lynah did not show any bismuth in the bronchi; it was only in the abscess cavities. While the bismuth was coming out of the abscess cavities into the bronchial tree, it was noted that it did not flow downward but upward, and roentgenograms taken at the time showed the middle and superior lobe branches well outlined by the opaque mixture while the lower lobe branches remained free. Shortly after the patient complained of such bubbling that he was compelled to cough, and expectorated about 2 c.c. of the bismuth mixture.

From these observations, Drs. Gottlieb and Lynah agree that probably there is another mechanism besides cough and the action of cilia which causes expulsion of secretions from the tracheo-bronchial tree.

Roentgenograms taken before the injection did not show a definite outline of the abscess.

Another injection of bismuth was made one month later, at which time the roentgenographic studies were made by Dr. Stewart at the Lenox Hill Hospital, who reported as follows:

"Fluoroscopic and roentgenographic examination, to ascertain how long the bismuth would remain in the abscess cavities and also how long it remained in the lobular structure into which it had infiltrated, showed that the bismuth mixture started to make its exit from the bronchial tree within a short time after injection. It remained much longer in the abscess cavities and lobular structures, but eventually disappeared." In abscess cavities it may remain from two weeks to two months, the shadow growing less opaque until it finally disappears. This perhaps ac-

counts for the improvement of the patient and the diminution of the quantity of pus expectorated and the disappearance of odor. The injection of bismuth mixtures, while done for the purpose of outlining the lung in order to locate definitely the abscess cavities, seemed to have a beneficial effect on the patient. There was no odor to the pus expectorated after the second injection; this was so pronounced that the patient noticed it himself and said that he no longer had a foul breath, for the bad smell and taste had disappeared.

This case is still under observation.

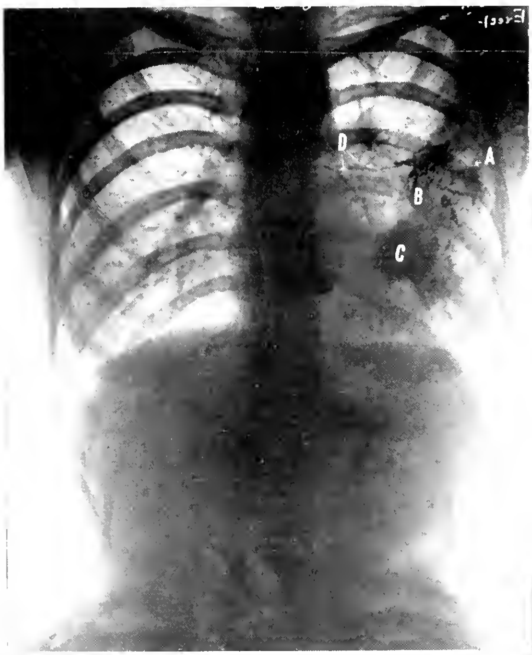


Fig. 5. Case II. Lung Abscess Directly after Injection. A. Abscess cavity outlined with bismuth suspended in sweet oil. B. Bismuth outlining small cavities surrounding large as well as dilated bronchial branches. C. Bismuth infiltrated into lung structure. D. Main bronchial branches.

Fig. 6. Case II. Lung Abscess Two Months After Injection. A. Remains of abscess cavity. B. Small amount of bismuth still remaining in contracted cavities. C. Remains of bismuth which infiltrated lung structure.

Case II. A young lady of twenty years was seen in consultation with Drs. Willy Meyer and Richard Jordan. The patient was admitted to the Lenox Hill Hospital and bronchoscoped shortly thereafter. Roentgenograms showed what appeared to be a very large abscess in the left upper lobe well out toward the periphery, which from the "pus soaked" spongy lung structure surrounding it appeared much larger than it really was, and also suggested some pleural involvement.

The patient had had a tonsillectomy performed one week before admission by an expert laryngologist. At the time of admission she was expectorating 250 c.c. of pus every twenty-four hours, and her general condition was poor.

Bronchoscopy with a 7 mm. tube showed pus pouring out of the bronchoscopic tube; all the pus having been sucked out, the left bronchus was entered. There was an edematous bronchial stenosis of the upper lobe orifice with a small opening from which free pus was expelled with each cough; in addition, a membranous plaque was present which also obstructed drainage from the upper lobe. The long slanting end of the 7 mm. tube was gently introduced into the

mouth of the upper lobe orifice separating the edematous stricture; the membranous plaque was removed by suction. After evacuating as well as possible the upper lobe branch, the lower lobe branches were examined but no pus was found in same. The upper lobe branch was again entered and the patient instructed to cough; with each expulsive cough there would be a gush of pus from this branch. The bronchus was apparently

FIG. 7. CASE III. BRONCHIECTASIS BEFORE INJECTION. A. Area of diseased lung with faint evidence of cavitation. B. Resected ribs. Thickened pleura. C. Thickened pleura right diaphragm "hooked up" with adhesions.

draining much more freely since the edematous stricture had been opened. With a 10 inch vacuum the bronchus was once more aspirated and after fifteen minutes the bronchoscopic tube removed.

The following week the patient had improved somewhat, but the amount of pus had not greatly decreased.

Dr. Lynah again bronchoscopically aspirated the upper lobe branch, and then decided to inject the bismuth and oil mixture in order to map out roentgenographically the abscess cavity. With the curved spiral cannula, 8 c.c. of bismuth subcarbonate in olive oil was injected too forcibly, so that some of it squirted out of the spiral and passed downward into the lower lobe branches (leakage out of the spiral will not occur if the bismuth is injected slowly, nor will it infiltrate the lobular structures of the lung). The upper lobe branches of the lung abscess were also injected, the bismuth sticking to the wall of the cavity and thus marking it out. Several smaller abscesses were now noted, whereas in the plate before injection the cavity was interpreted as being very large. The bismuth mixture did not infiltrate the lobular structures in the upper lobe. Stereoscopic plates showed the abscess cavities well anterior and out toward the periphery, while the mass, which had leaked down into the lower lobe branches, was well posterior. A lateral plate taken at this time showed the relations of the upper anterior lobe abscess cavity, which was clearly defined, to the posterior dull opaque fan-shaped areas due to gravitation into the dorsal branch.

The bismuth was expelled from the lung, as in the other patient, within twenty minutes after the injection. As some of the bismuth had leaked downward into the lower lobe branches, it was impossible to state whether or not the bismuth started immediately to be expelled outward, as in the first patient, or whether it had gravitated into the lower lobe branches after it started to be expelled.

The patient was studied from time to time with the fluoroscopic screen and further roentgenograms taken. At the end of one week there was still bismuth present, both in the abscess cavity and in the lower lobe of the lung where no abscess existed; this looked somewhat like an abscess cavity, but was seen roentgenographically as an irregular area of opaque dullness, and did not have the metallic luster of the bismuth in the abscess; this is one of the distinguishing points between infiltration of bismuth into the lobular structure of the lung and bismuth in an abscess cavity.

The patient improved after the injection,

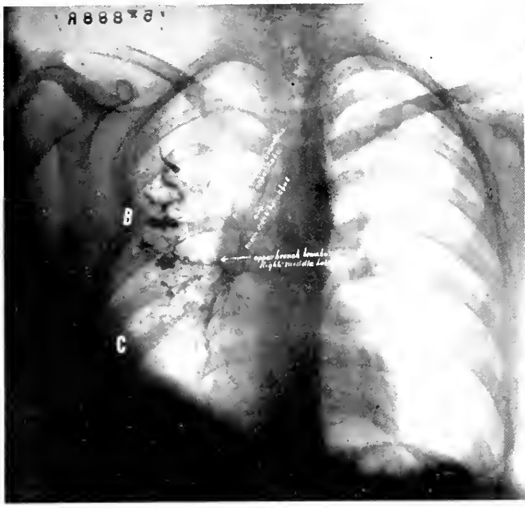


Fig. 8. Case III. Bronchiectasis Immediately after Injection. A. Cavities mapped out with bismuth suspended in sweet oil. B. Resected ribs. Thickened pleura. C. Thickened pleura. Right diaphragm "hooked up" with adhesions.

Fig. 9. Case III. Bronchiectasis Six Weeks After Injection. A. Involved area of lung free from bismuth. B. Resected ribs. Thickened pleura. C. Thickened pleura, diaphragm caught in mass of adhesions.

in a manner similar to Case I. The pus decreased from her lung, and the amount of measured sputum in twenty-four hours decreased from 250 c.c. to 30 c.c. The odor was decidedly less and the patient's general health improved.

Bismuth was still present in the lung when fluoroscoped ten days after injection, although both shadows were diminishing in density and the lung abscess was apparently clearing up.

The patient suffered no discomforts following two injections of bismuth into her lung. She ate and slept well and had but little cough. She was bronchoscoped twice after the injection and we were not able to recover any of the bismuth by suction, even though it was still present in the lung. At a later bronchoscopic examination there was very little pus recovered by suction and no pus was expelled from the bronchus when the patient was instructed to cough.

The patient is still under observation.

Case III. A female, S. M., age twenty-five years. On March 26, 1918, she had her tonsils and adenoids removed. Ten days following the operation the patient began coughing

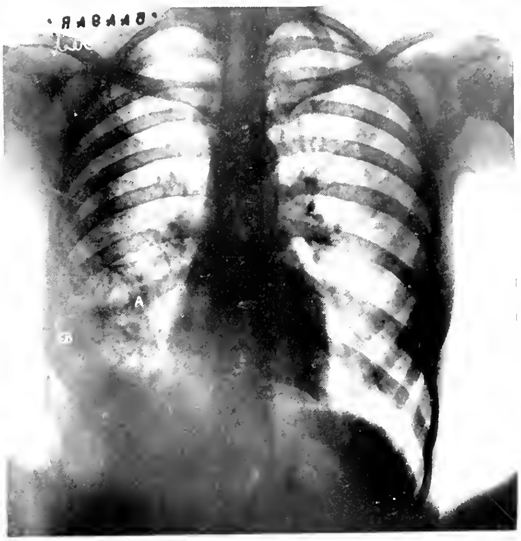


Fig. 10. Case IV. Bronchiectasis. Before Injection. A. Area of cavitation. B. Fixed diaphragm with thickened pleura and bands of adhesions.

up small quantities of foul-smelling sputum, thick and yellowish in character; the amount gradually increased and occasionally the sputum was streaked with blood. There was pain and soreness in the lower part of the chest.

She was operated in May, 1919. Rib re-

section was performed and the cavity Dakinized; no abscess was found. The following September the incision was reopened and the tube placed in the cavity; there was no drainage; very little improvement occurred. In November, 1919, a new incision was made lower down with resection of a rib; a tube was left in the cavity, but no drainage occurred. In January, 1920, the incision was reopened and extended backward. An abscess was opened and a tube left in for drainage, which amounted to four ounces on the first day and two ounces on the second day. The discharge gradually decreased, the tube was removed and the wound healed.

About six weeks later she began coughing and raising foul-smelling sputum again and gradually became worse until she was admitted to the Lenox Hill Hospital on May 17, 1920.

On May 22, 1920, a preliminary fluoroscopic combined with stereo-roentgenographic examination showed evidence of pleuritic thickening involving the upper and middle lobes on the right side; the right diaphragm was partially fixed with adhesions. In the lower portion of the upper right and the upper portion of the middle right lobes there was increased density with here and there evidence of cavitation.

The patient was bronchoscoped on May 25, 1920. Abundant purulent secretion was discharging from the upper lobe; 8 c.c. of a mixture of bismuth subcarbonate in sterile olive oil (1–2) was injected in the upper lobe bronchus; this was followed by a fluoroscopic as well as a stereo-roentgenographic examination which showed that some of the bismuth mixture had reached the diseased area, but not sufficient to map out the cavities satisfactorily.

A roentgen re-examination on June 9th showed much the same condition as reported on May 22d. Most of the bismuth had disappeared.

On July 8th the patient was again broncho-

Fig. 11. Case iv. Bronchiectasis. Immediately After Injection. A. Area of cavitation outlined with bismuth suspended in sweet oil. B. Thickened pleura with adhesions. Right diaphragm "hooked up" and fixed.

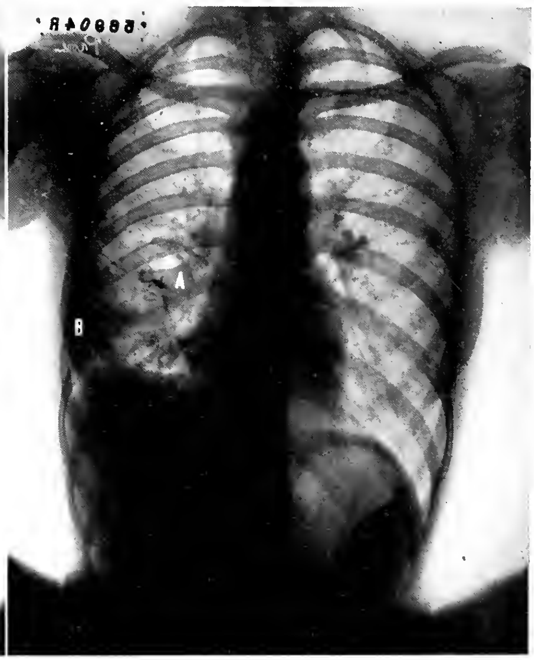


Fig. 12. Case iv. Bronchiectasis. Four Months After Injection. A. Area of cavitation. Small amount of bismuth still present. B. Some clearing of lung at right base. Thickened pleura with adhesions. Right diaphragm "hooked up" and fixed.

scoped, the main upper lobe being injected as previously. The stereo-roentgenograms, taken almost immediately after the injection, showed with excellent detail the numerous cavities in the lower portion of the upper and the upper portion of the middle right lobes.

The patient is still under observation and shows continued improvement.

Case IV. A. L., a young girl twenty years

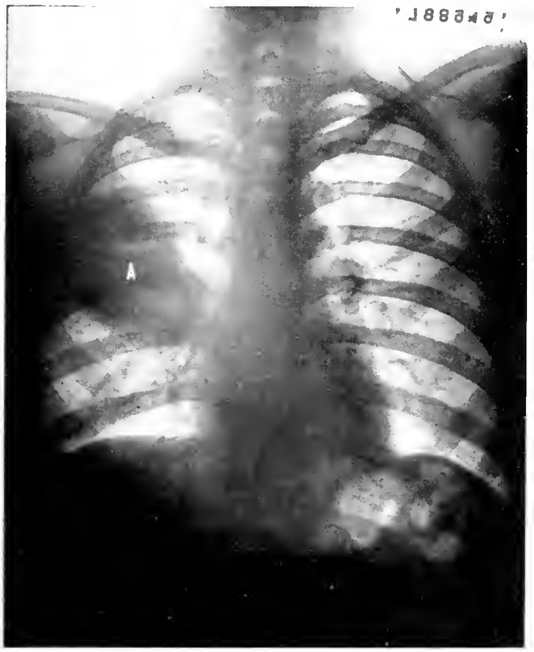


Fig. 13. Case v. Lung Abscess. One Month Before Injection. A. Lung abscess showing fluid level with air bubble above cavity surrounded by pus-soaked infiltrated area of lung structure.

old, was admitted to the Lenox Hill Hospital in June, 1920, with the following history:

Tonsils had been removed two years previously. Following the operation she was taken home in an open car, with considerable exposure. Pneumonia developed; the cough continued, and two weeks later she began expectorating large quantities of foul smelling pus. This condition persisted up to the time of her admission to the hospital.

A preliminary fluoroscopic combined with stereo-roentgenographic examination, on June 19, 1920, showed marked pleuritic thickening over the middle and lower right lobe; the right diaphragm was "hooked up" with adhesions and there was considerable increased density in the middle and lower right with evidence of cavitation, especially in the lower lobe.

June 20, 1920, bronchoscopic examination showed pus coming from the middle and lower right lobes; none from the upper. A mixture of 8 c.c. of bismuth subcarbonate in sterilized olive oil was injected into the bronchi of the middle and lower right.

Roentgen examination, made as soon as possible after the injection, showed the bronchi within the diseased area well outlined, with numerous cavities clearly demonstrated.

When the patient entered the hospital she expectorated 300 to 500 c.c. per day. Since the injection gradual improvement has occurred with marked diminution in the quantity of expectoration.

The patient is still under observation.

Case V. E. E., male, age twenty-four years, entered the Lenox Hill Hospital on June 18, 1920, with following history:

Had tonsils removed June 5, 1920; six days later developed a cough which became productive on about the ninth day. On admittance his chief complaint was cough with expectoration, and pain in the joints.

June 23, 1920, a preliminary roentgen examination was made which revealed a dense triangular area in the lower portion of the upper right lobe; in the center of this pus-soaked, spongy area of infiltrated lung tissue, a fluid level with an air bubble above could be made out, indicating a large abscess.

On June 29th he was bronchoscoped, a 9 mm. tube being used. Pus was seen coming from the right upper lobe bronchus only. About 10 c.c. of bismuth subcarbonate in sterilized olive oil (1–2) was injected into the right upper bronchus; this was followed by roentgen examination which showed the lower bronchus outlined by the injection, very little if any having passed into the diseased area.

He was again bronchoscoped on July 8th. Pus was still obtained from the right upper bronchus which was again injected with bismuth suspension. Fluoroscopy and stereoroentgenograms showed bismuth outlining the numerous cavities; some of the mixture had infiltrated into the lobular structures well out toward the periphery of the upper portion of the dense area.

The quantity of sputa gradually diminished until July 19th, when it had practically disappeared and the arthritic symptoms had greatly improved.

A stereo-roentgenographic re-examination on July 26th showed gradual disappearance of the bismuth except where it had penetrated the lobular structures.

The patient is still under observation.

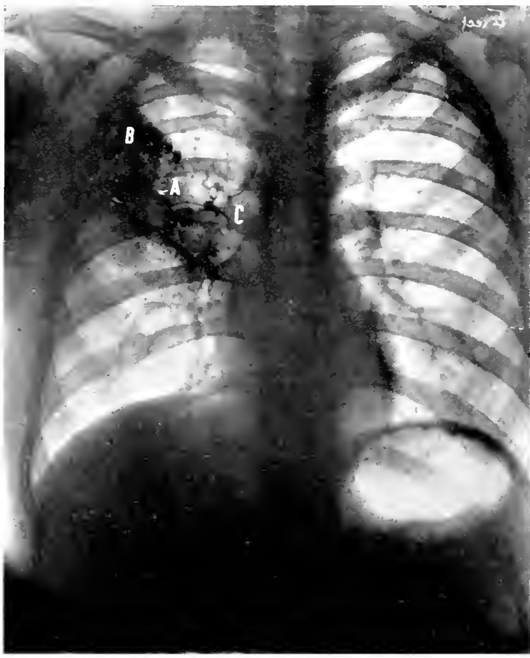


Fig. 14. Case v. Lung Abscess. Directly After Injection. A. Lung abscess mapped out with bismuth subcarbonate suspended in sweet oil. B. Bismuth infiltrated into lung structure.

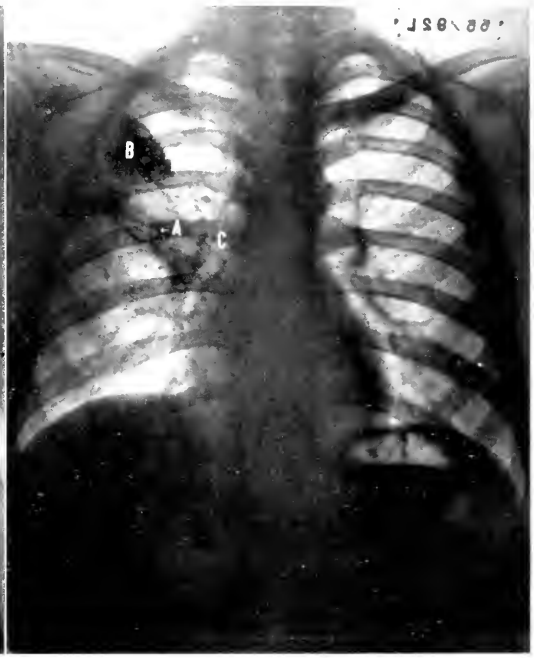


Fig. 15. Case v. Lung Abscess. Three Weeks After Injection. A. Remains of cavity. B. Bismuth infiltrated into lung structure. C. Dilated right bronchus.

SUMMARY

1. Bismuth mixtures can be injected into the bronchi and lungs of a living patient without danger.

2. The injection of an opaque substance into the lung of the living patient will open an enormous field of usefulness in the study of cough, the expulsion of substances from the lung, and lung drainage. It will also aid in localizing bronchial strictures in the same manner as in the esophagus. Furthermore, it will be of the greatest aid to the thoracic surgeon by mapping out the abscess cavity in the respective lobe of the lung.

3. A definite lung abscess cavity is seldom seen bronchoscopically. Pus is usually seen coming from a branch bronchus, although the abscess may be well around the corner, and not in that portion of the lung from which the pus is oozing. An injection of bismuth mixture or some other opaque mixture will "clear up" this error.

4. Bismuth, when it enters the abscess cavity, is recognized by its metallic luster, whereas when it is in the lobular lung structure, it is discerned as a dull opaque area. Pus diffuses and soaks the lobular structure in a manner similar to bismuth; this often

makes the involved area appear many times larger than it really is.

5. The bismuth mixture injected in these patients was 8 c.c. of bismuth subcarbonate in pure olive oil (1–2). The mixture is rendered sterile by boiling before injection.

6. The injection should be made slowly and not with a "squirt," or else the roentgenographic observations may be spoiled by bismuth soaking the lung structure surrounding the diseased area.

7. It seems from these preliminary studies that cough and action of cilia are not the only means of expelling secretions.

8. While bismuth mixtures were originally injected for the purpose of lung mapping in cases of lung abscess cavities, they seem to have been of therapeutic benefit to the five patients upon whom they were tried. So far the procedure has done no harm.

9. While the fluoroscopic examination is important, stereo-roentgenographic examination is the best means of localizing the cavitations.

10. Experience has shown that the roentgen examination should be made almost immediately after the removal of the bronchoscope, otherwise the patient, in a fit of coughing, will remove much of the bismuth from the involved lung.

DISCUSSION

Dr. David R. Bowen. In the slide that was shown of Dr. Jackson's case the remarkable thing was that this plate was made on the fluoroscope with double screen. We hurried the patient to the stereoscope, and there was nothing there, although it could not have been more than fifteen minutes.

Dr. W. F. Manges. I should like to ask Dr. Stewart why he uses so much bismuth, why the mixture is so concentrated. This is a rather big field for study, and I wonder if it would not be well to advise a bit of caution. It seems to me that one should first be sure that he has the proper facilities for taking care of emergencies. Unless one has the association of a competent bronchoscopist, the procedure had better not be started. I think those of us who are in laboratories where there are efficient bronchoscopists, where there is every means for taking care of emergencies, ought to do everything we can to continue and work with Dr. Stewart alone these lines, and see if the end results are going to be right.

It seems to me that since a foreign body in the lung tissue must be removed sooner or later, for eventually the foreign body in the lung is apt to set up a suppurating process, I do not see why bismuth should not act as a foreign body in the lung tissue that has not been previously walled off by fibrous tissue—why it should not become a foreign body because of its metallic properties.

Dr. W. C. Hill. I should like to ask Dr. Stewart whether, in any of these cases where the bismuth was retained a month, there were any symptoms of bismuth poison, not nitrate poisoning, but bismuth poisoning. I know of two deaths from bismuth poisoning and I saw another case, a child, who was closely following the course of the others when I saw it, and advised evacuation of the bismuth.

Dr. G. E. Pfahler. I would like to compliment Dr. Stewart on his brilliant work, as well as the daring which led him to undertake it, but I would like to ask whether there is any benefit to the patient, or whether the benefits are purely diagnostic—whether the method has a therapeutic value to the patient other than simply to outline the abscess cavity for the benefit of the surgeon. We must, after all, consider how much good this is going to do the patient.

Dr. P. M. Hickey. I, too, would like to compliment Dr. Stewart on this pioneer work, and would like to take up the cudgel in its behalf. It is quite possible for a foreign body to remain in the lung without setting up irritation. I have two plates in the exhibit room—one a child who had a peanut in the lung for five weeks, and the other for two weeks. When I introduced the bronchoscope, there was no appearance of secretion. The bronchus was perfectly clear.

During this discussion, I have been thinking over some work I knew about some years ago, when a friend of mine injected the trachea and bronchi daily with a laryngeal syringe for

chronic cough. The solution he used was olive oil and guaiacol. He used it in considerable quantities, and it seemed to be a soothing application.

If the bronchoscopy is done by a competent man, the injection of a small amount of sterile solution in the bronchus, I believe, can have no deleterious effects. It is certainly a very brilliant thing to be able to map out the bronchi in the way it has been done. It would, of course, be easier to collapse the lung and get rid of the abscess in that way, but this new method is important in that one is able to demonstrate in these cases the exact extent of the pathology present. It seems to me that, from a theoretical standpoint, there can be no danger to the patient, inasmuch as you use only a local anesthetic.

Dr. F. F. Borzell. It seems to me that there is considerable weight to Dr. Manges' statements. It might be true that when the bismuth is first injected, it is sterile; and I do not doubt that many of our foreign bodies which are inhaled are sterile at the time of inhalation; but with the bronchioles being constantly subjected to infection from without no foreign body would remain in the bronchiole for any length of time without becoming infected, resulting in the varied pathology one sees with any other infected foreign body in the bronchial system.

Dr. James T. Case. Are there any further discussions? If not, I should like to speak of my own experience in this matter. I have known of two deaths following the actual inspiration of barium-mixed food into the larynx, in one case the mixture being only barium and water. This was a case of carcinoma of the esophagus. One case I have especially in mind was one in which Dr. L. L. McArthur injected a bronchial cyst which had a pharyngeal opening. In the injection, a fairly large quantity of the bismuth mixture was used, the injection being done about five o'clock in the afternoon. During the night, the patient had a sudden fit of coughing. The next morning, she was brought to the x-ray room to see what had happened. The entire bronchial tree was distinctly filled with bismuth. Following this, the patient had a most violent case of multiple abscess of the lung, and it was a miracle that she lived through it; but she finally made a complete recovery.

Dr. W. H. Stewart. I expected, of course, a certain amount of criticism, and am very glad to have had the discussion entered into as it was. I always have a great regard for the opinion of Dr. Manges, as I believe he is one of the most conservative men in this particular line, and I have to voice his ideas, that it must not be taken up promiscuously, that the work must be done by an expert bronchoscopist, but it can be done absolutely without danger. It is really remarkable, gentlemen, that every one of the five cases reported this evening, wrote Dr. Lynah and asked for a re-examination, because they had received so much benefit from the bismuth injection. There is no question of the therapeutic value of this procedure to the patient. In one case the amount of expectoration was reduced from 500 c.c. in twenty-four hours to 30 c.c. in twenty-four hours. Whether or not a cure will be effected, we are unable to say at the present time, nor are we able to say whether the bismuth which infiltrated the lung structures will cause any further trouble. It has not up to the present; it is gradually disappearing and does not seem to act as a foreign body. I believe it will gradually disappear without any inconvenience. We have observed these cases for only six months; all are under close observation, however, and will be watched carefully.

In regard to the opaque solution—Dr. Lynah tried thorium and other mixtures of like character. He found that bismuth subcarbonate and sweet-oil was *the one* non-irritating mixture; it does not seem to trouble the patient in the least.

Dr. Hill asked regarding bismuth poisoning. I can emphatically state that never, in any way, has there been any evidence whatsoever of bismuth poisoning. As stated before, the patients were all benefited to such an extent that each and every one wrote a letter asking to come back to the Hospital for another injection.

With regard to the benefit to the patient, as asked by Dr. Pfahler, there seemed first to be the diagnostic element, and second, the therapeutic effect. Dr. Lynah questions in his own mind whether the benefit is due to the bismuth

in the lung or whether to the fact that the bronchoscopy opened up the bronchi and allowed a free drainage of the lung. At the present time I believe both elements enter into it. Dr. Borzell, I think I have answered in regard to the retention.

With regard to Dr. Case's experience, it is impossible for me to say why this case should have such untoward effects. It may be that the injection was not made with the same precautions which Dr. Lynah uses in making his injections.

I am very sorry that Dr. Lynah is not here. He is a brilliant speaker, and would be better able to defend his position than I, who only take up the *x*-ray side of the question.

THE BUCKY DIAPHRAGM PRINCIPLE APPLIED TO RADIOGRAPHY OF THE SPINE*

By H. E. POTTER, M.D.

CHICAGO, ILLINOIS

My object in presenting this short paper on radiography of the spine is not for the sake of reviewing the well-known pathologic conditions in which *x*-rays have proven of diagnostic value, or of calling attention to their differential features, but to set before you for your criticism a series of technical results made by a method with which you are familiar in theory but which, as far as I am able to learn, has not been used in a practical routine manner outside of our laboratory.

Those who are not familiar with the work we have been trying to do in adapting the Bucky diaphragm principle to practical radiography may be referred to the article published in the June number of our Journal. This takes up the construction of a parallel grid which moves between patient and plate during an exposure and serves to absorb a large number of the obnoxious scattered rays, while its simple movement serves to neutralize its own shadow. Attention was called to the larger number of scattered rays present in penetrating the deeper portions of the body, such as the abdominal or pelvic region. For this reason, in combination with one other, we have chosen to exemplify first the results obtainable in radiography of the spine. The other reason is that with crude apparatus of our own construction the element of time in grid movement has prevented the extremely rapid exposures desired in working with the moving viscera. We may say that since February of this year all

Fig. 1. Fractured Lamina of First Lumbar. Compression of Second.

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

our spine cases have been handled by this method, and in the last months all of the kidney and gall-bladder cases.

The net results of the method are to give us plates which show a heightened contrast between bony and other structures, and a greater clearness in the more delicate structures of the spine complex in as large a section of the spine as is desired. It necessarily follows that the gross lesions can be studied more comprehensively and the minor or beginning lesions brought to light with greater certainty. In the latter years we have all become used to seeing the most critical radiographs of the extremity bones, and we shall all admit, when we stop to think, that in the most important spine cases the diagnosis is often made possible by the last 10 or 20 per cent in the technical excellence of the plates. We believe that shortly the Bucky diaphragm method will form a basis for obtaining results on the spine which are entirely comparable to those obtained on the extremities, and at this time we wish to record systematically a number of respects in which the method has materially helped us in our diagnostic efforts:

1. In the recognition of tuberculosis and metastatic carcinoma. Early tuberculosis and beginning metastasis are deservedly subjects which give the roentgenologist great concern on account of their clinical significance and general difficulty of recognition. The large comprehensive plates have more than once yielded unexpected information a few inches higher or lower than was clinically suspected. Slight or suspicious changes in any anterior portion of the vertebral body

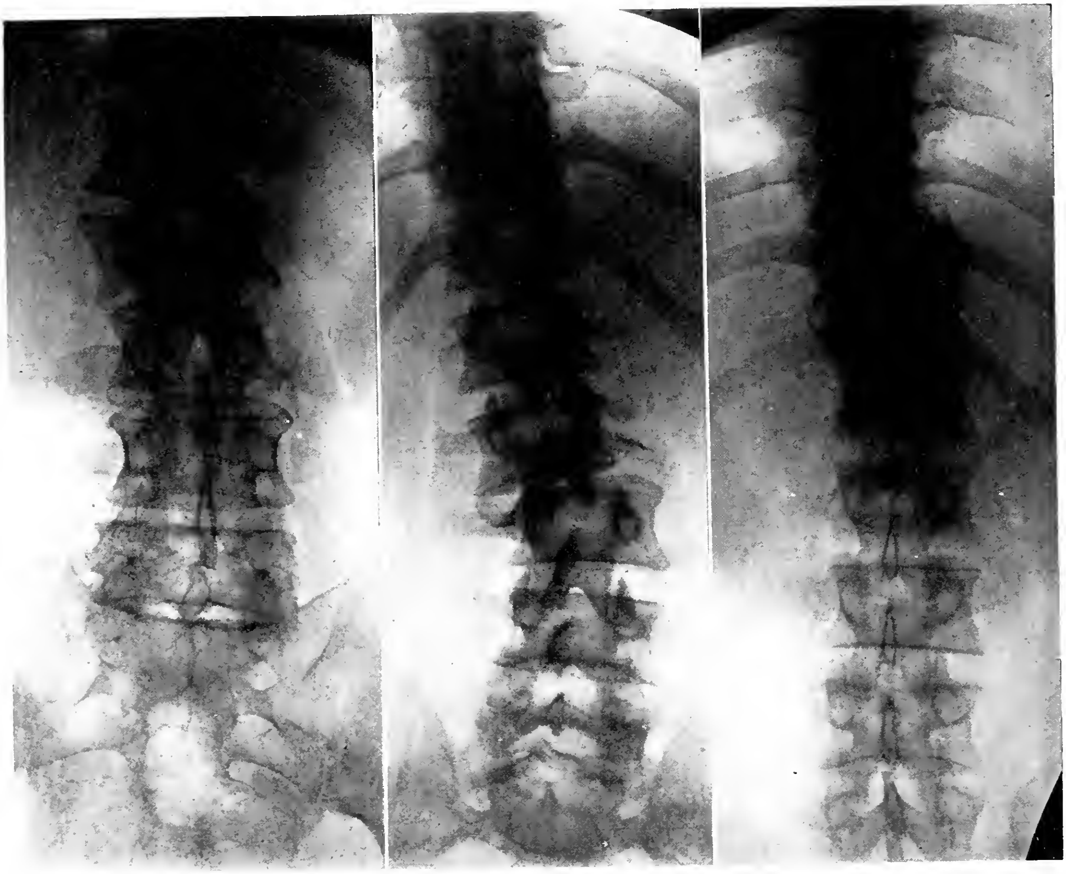
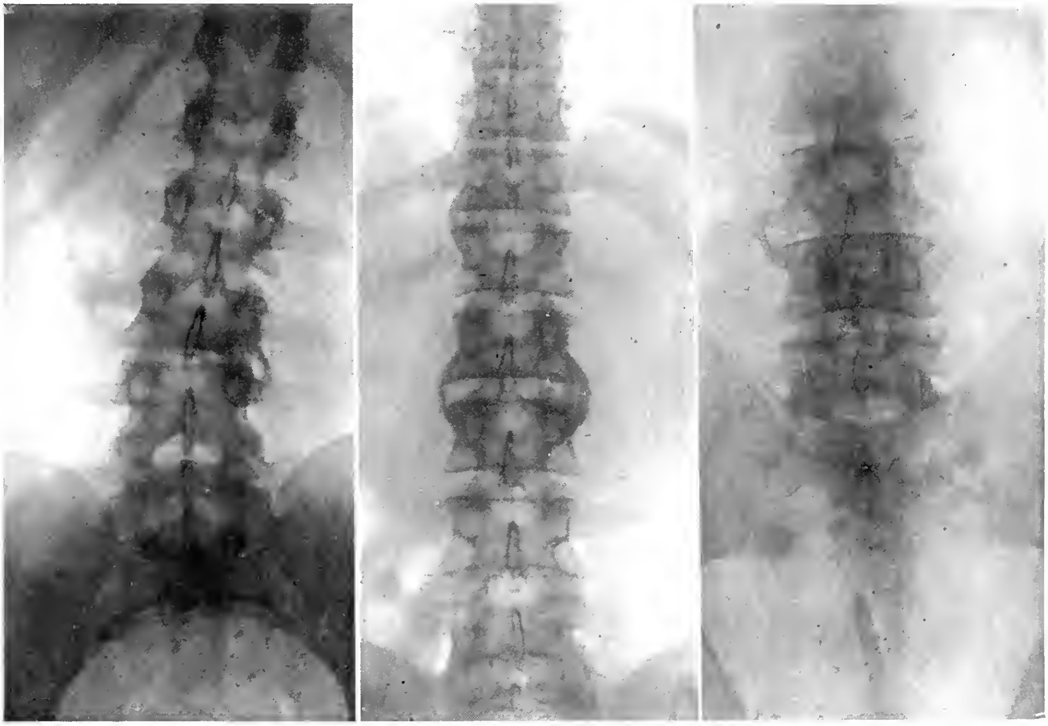


Fig. 2. A Few Fractured Spines Showing Large Scope of Exploration without Sacrifice of Radiographic Quality.

have been followed up by plates projected obliquely or laterally so as to bring the suspicious point into profile, with the result that the suspicion was turned into a diagnosis.

2. This ability to obtain critical plates in oblique or lateral positions has many times resulted in the graphic measurement of slight impactions to the bodies of vertebrae where such could scarcely be known to exist by any simple or stereoscopic series made from in front. The general value of lateral spines has been brought out in this Society by Hickey and others. The Bucky diaphragm method offers us the easiest means of obtaining results in this most difficult technique.

3. This filtering method makes possible much more critical study of antero-posterior plates of the middle and lower dorsal vertebrae. Vertebrae lying above the diaphragmatic line have a peculiar anatomic relationship, in that on either side the air-filled lungs easily transmit rays which flood into the central plate area before the denser spinal structures have been fully recorded. It was one of our surprises to see how the plates with the Bucky apparatus prevented this source of fog and gave us the same clean results obtainable elsewhere.



A B C

Fig. 3. Deep Osseous Radiography for Disease.
A. Tuberculosis with Bony Reaction. B. Typhoid Spine, after eight months. C. Metastatic carcinoma of prostatic origin. Hypertrophic Arthritis.

4. In the study of the pelvic structures the method has been gratifying on account of our ability to obtain a comprehensive plate of the whole pelvis without losing the details about either the hip-joints or the sacro-iliac region. Fractures of one portion of the pelvic ring are so often associated with a second fracture elsewhere in the pelvis that comprehensive plates should be re-

lied upon for the whole of the truth, particularly if radiographic detail can thus be preserved.

5. In cases of old minor injuries to the lumbar spine, associated with traumatic or other arthritis, or with callus formation, when structures of the pedicle and not the bodies have been fractured, etc., nothing short of the most excellent plates by this or any other method can lead one to a justifiable diagnosis, fully protected and set aside from the anatomic architectural peculiarities common in the lower spine.

These in brief are the advantages which we believe have been observable in our routine work. There is one disadvantage which can be seen in an inspection of any series of our plates. The osseous structures are slightly enlarged because of the increased distance between patient and plate, and when a large focus tube is used the hard lines lose somewhat of their sharpness. This disadvantage can be corrected somewhat by the use of fine focus Coolidge tubes, increasing the tube distance and using a grid of greater fineness and less depth.

DISCUSSION

Dr. B. C. Darling. The opportunity to make the large-sized plate seems to me is a distinct advantage. There has always been a limitation, for in order to get satisfactory plates, we had to use a small cone. By this method, we will be able to use more 11 x 14 and 14 x 17 plates, and we will get much finer detail by this method. The hardest thing to get is thus made easier, and in this way our diagnostic ability will be improved.

I had the pleasure of seeing this apparatus in Dr. Potter's office the other day, and he cer-

A B C

Fig. 4. A Few Lateral, Semi-Lateral or Near-Lateral Spines.
A. Lateral from Figure 3-A. B. Normal lateral for scope. C. True lateral in compression fracture.

tainly has something worth while. He has something that, if mechanically perfected, will be of great value.

Dr. P. M. Hickey. Last summer I had the pleasure of visiting Dr. Potter's office, and seeing a demonstration of how this diaphragm works, and the plates which he has I have never seen equaled, either in number or quality. It is a wonderful thing that roentgenography of these parts of the body, which heretofore has been so difficult, can be brought out with such a wealth of detail.

Dr. Isaac Gerber. I would like to know whether Dr. Potter has found that the use of this diaphragm was interfered with at all in double screen and film work, or whether all of his exposures are made on straight plates or films.

Dr. H. E. Potter (Closing). The first exposures were made with plates entirely, and this seemed pretty hard on the thirty milliampere Coolidge tubes, so all the rest of the exposures have been made with double screen film, which is very much easier on the tube and simpler in technique. The double screen greatly aids instead of interferes with the method.

PNEUMOPERITONEUM AS AN AID IN THE DIFFERENTIAL DIAGNOSIS OF DISEASES OF THE LEFT HALF OF THE ABDOMEN*

By A. F. TYLER, B. Sc., M.D., F. A. C. P.

OMAHA, NEBRASKA

SINCE this paper is part of a symposium on the use of gas in the peritoneal cavity for diagnostic purposes, I am definitely limited in my discussion to the use of this method as an aid in the diagnosis of diseases of the left half of the abdomen.

Because of the fact that many cases complaining of vague symptoms on the left half of the abdomen present themselves for examination, it occurred to me when I began using this method of diagnosis that such aid might be of considerable use in clearing up this type of obscure cases, so that it has been my custom when I am unable definitely to locate pathology in the left half of the abdomen by the usual physical examination and the opaque meal examination of the gastro-intestinal tract, to employ pneumoperitoneum as a further method of investigation. We have been happily rewarded in many of these obscure cases, a few of which will be mentioned in the body of the present paper.

In reviewing my experience with pneumoperitoneum it has occurred to me that the greatest percentage of cases in which it has been definitely helpful have been those with some form of left-sided pathology. In order that we may lay proper foundation for pathological discussion, let us review for a moment the anatomy of the left half of the abdomen in relationship to findings demonstrable by penumoperitoneum. When the abdomen is filled with gas, it is possible to see clearly the outline of the diaphragm stretched across from the center to the left ribs and above this, of course, the lung in the chest cavity. Below it can easily be demonstrated that the spleen, and in many cases even the pedicle of the spleen, can be readily seen. Near the central portion of the left half of the abdomen can be seen the left kidney in toto. In some cases the left lobe of the liver can be visualized together with the tail of the pancreas. In other cases one will see a band extending across from the left parietal

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

wall of the abdomen over toward the center, which is only the mesenteric attachment of the splenic flexure of the colon. One must be careful that this is not interpreted as pathological. Having these essential anatomical points in mind, it is then not difficult to determine what is pathological.

Patients frequently present themselves for examination complaining chiefly of colic in the left side which on investigation may prove to be renal or ureteral in type or perhaps colonic in origin. They will complain of an indefinite dragging or pulling sensation which is worse in the erect position and is relieved by lying on the back or on the left side. We are compelled in these cases then, to differentiate between diseases of the kidney, of the left colon, of the spleen, of the pancreas, of the left lobe of the liver and retroperitoneal new growth. In the colon we must differentiate between spastic or ulcerative colitis, adhesions, diverticula and new growths. In the kidney, we must differentiate between stone, pyelitis, tuberculosis, hydronephrosis, new growth, supernumerary kidney, ureteral plug or kink. In the spleen, we must differentiate between the different leukemias, enlargement from malaria, syphilis, hemolytic icterus or Banti's disease and perisplenic adhesions. In the pancreas we must differentiate between cyst and pancreatitis. The left lobe of the liver must be differentiated from the pancreas, the spleen and the kidney. We may further find adhesions of the various organs one to the other or to the parietal peritoneum. We may, in some cases, find a retroperitoneal new growth, such as a large retroperitoneal sarcoma recently demonstrated.

Fig. 1. Case No. 13965.—Large Retroperitoneal Tumor with Kidney Showing Above and Distinct from the Mass. Proven at operation to be sarcoma.

Fig. 2. Case No. 13965.—An Oblique View of the Same Patient as Shown in Figure 1, Showing the Kidney Separate from the Mass.

In speaking of the differential diagnosis in these various conditions, it is my thought that this differential diagnosis cannot be complete in any case without thorough physical examination, including the x-ray examination and the different laboratory tests, together with catheterization of the ureter and other methods usually employed for eliminating or confirming diagnosis; so that in my

presentation of this subject, I take it for granted that all of these different methods are being employed along with pneumoperitoneum, as Case and others have shown that diverticula of the left half of the colon are not infrequent and when carefully searched for are quite readily demonstrated by the usual opaque meal and similar methods of examining the gastro-intestinal tract. As a rule the spastic or ulcerative colon can be demonstrated roentgenologically in the same manner. New growths in the left half of the colon are readily demonstrated by the opaque method. Stone in the left kidney is demonstrated without the use of pneumoperitoneum; but in some cases there is a question as to whether the shadow is really a kidney stone or a calcareous mesenteric gland, and pneumoperitoneum will help us to differentiate, especially when catheterization of the ureter is impossible. Hydronephrosis can readily be demonstrated by injection of gas into the peritoneal cavity, as well as new growths involving the kidney, or retroperitoneal space. Different types of enlarged spleen can be demonstrated by pneumoperitoneum, but must be differentiated by the complete blood count and different laboratory methods. Cysts of the pancreas can be positively proved by pneumoperitoneum better than by any other method. Adhesions to the various organs can be actually visualized by the injection of gas into the peritoneal cavity, clearing up many obscure cases.

Fig. 3. Case No. 13285.—A Dense Band of Adhesions Stretched across from the Colon to the Left Side of the Parietal Peritoneum. On inspiration, the spleen presses down against the band, as shown in the cut. On expiration the spleen moves away from it.

Fig. 4. Case No. 12880.—Large Cystic Ovary, Accompanied by Multiple Fibroid Tumors of the Uterus. Proven at Operation.

CASES

Case 13844: Mrs J. M. B., age thirty-three years.

History.—When the patient was twelve years old she had an attack of bilious fever with jaundice. For seven years she has had pain in the left upper quadrant of the abdomen, which radiates to the back and varies in intensity. She has abdominal distension with gaseous eructations, nausea, but no vomiting and no jaundice.

Physical Examination.—There was a palpable tender mass in the left upper quadrant of the abdomen and slight tenderness in the right upper quadrant.

Roentgen Examination.—This revealed a large soft tissue shadow in the left upper quadrant which has the contour of a kidney.

Pneumoperitoneum proves that the shadow is the left kidney, the spleen being normal in size. There are perisplenic adhesions from the spleen to the diaphragm. The stomach is normal in shape, size and position, empty in six hours. The duodenum is normal. The appendix has been previously removed. The cecum and colon are normal in contour, low, but freely movable.

Diagnosis.—Enlarged left kidney; perisplenic adhesions.

Case 13440: Miss A. D., age thirty-four years.

History.—For five years patient has been having attacks of abdominal distress, which usually last several weeks, characterized by a feeling of fullness or pressure in the epigastrium and in the left side of the abdomen, extending into the back.

Physical Examination revealed a definite tenderness in the lower right quadrant of the abdomen. Examination otherwise negative.

Roentgen Examination.—The stomach is normal in shape, size and position; empty in six hours. The duodenum shows spasm. The appendix has been previously removed. The cecum and colon are normal in contour and freely movable.

Pneumoperitoneum shows adhesions extending from the left parietal peritoneum across to the greater curvature of the stomach.

Diagnosis.—Perigastric adhesions involving the greater curvature.

Case 12846: Miss J. G., age twenty-four years.

History.—Patient complains of splashing in the stomach accompanied by pain and vomiting. She was examined by me in March, 1918, at which time a diagnosis of chronic appendicitis was made. This was followed immediately by an appendectomy. In July, 1918, a gastro-enterostomy was done. She has not been well since.

Physical Examination.—Patient was of the enteroptotic type. There was dullness in both apices of the lungs with râles in the left apex and left axilla.

Roentgen Examination shows the opaque meal passing through the gastro-enterostomy opening. The chest shows increase in both hila. Peri-bronchial infiltration well up in both apices. Multiple areas of consolidation in the left upper lobe.

Pneumoperitoneum shows a few adhesions to the abdominal wall at the scar. The shadows of both kidneys are visible. Folds of soft spleen, the uterus, tubes and ovaries are demonstrated.

Diagnosis.—Pulmonary tuberculosis. Abdominal adhesions.

Case 12355: Mrs. G. H., age forty-five years.

History.—Patient has been constipated for many years. For the past ten years she has had a tender point a little to the right and below the umbilicus. She now has constant pain which radiates to the right thigh and to the back, but it is never very severe.

Physical Examination.—Negative except for general abdominal tenderness with the maximum point one inch to the right of the umbilicus.

Roentgen Examination.—The stomach is normal in shape, size and position; eight ounce residue at five hours. The duodenum is normal. The cecum is not freely movable. The colon is normal and freely movable. The appendix is not visualized.

Pneumoperitoneum shows adhesions extending from the left side of the colon near the splenic flexure over to the parietal peritoneum near the costal arch.

Case 13346: Mrs. F. H., age twenty-nine years.

History.—One year ago the patient had her appendix removed. Two years prior to her operation she had indigestion and pain

in the epigastrium with occasional vomiting. Since the operation, she has had a dull gnawing pain in the right upper quadrant. This pain is relieved by lying down. There is a feeling of fullness after meals.

Physical Examination shows marked tenderness in the right upper quadrant of the abdomen.

Roentgen Examination.—Filling defect on the lesser curve near the pylorus, probably spasm, no tender point; empty in five hours. The duodenum is normal.

Pneumoperitoneum shows a band of adhesions to the colon near the splenic flexure, against which the spleen is pressed on deep inspiration. A band of adhesions from the scar in the right iliac fossa to the head of the cecum is also demonstrated.

Fig. 5. Case No. 12846.—Spleen Showing Typical Folds Frequently Noticed at Postmortem Examination in a Soft Flabby Spleen.

Fig. 6. Case No. 133440.—Arrows Point to Bands of Adhesions Extending across from the Greater Curvature of the Stomach to the Left Parietal Peritoneum.

Case 12973: Mrs. T. E. A., age forty-one years.

History.—Three months previous to examination the patient noticed that the abdomen was growing larger. This gradually increased until the time of the examination. At the time of the examination the enlargement extended up under the right ribs.

Physical Findings revealed a large uterus which nearly filled the entire abdomen. The mass was smooth except for several nodules on the upper anterior aspect.

Pneumoperitoneum shows a fibroid tumor of the uterus plus pregnancy. One month later: Fetus is not visualized, but fluid in the uterus is demonstrated.

Case: Miss M. E. Age nineteen years.

History.—About two years ago patient began to have pain and swelling in feet and arms which was worse at night. She had a cough and pain in the chest, and night sweats once in a while. She was so weak at times that she could not walk upstairs.

Roentgen Examination.—Peribronchial infiltration well out in both lungs. Both sides of the diaphragm move freely.

Pneumoperitoneum shows the liver, both kidneys, tubes, uterus and left ovary normal

in size and position. No abdominal adhesions. Cyst of the right ovary.

Diagnosis.—Cystic right ovary.

Case: Mr. J. C., age forty-nine years.

History.—About one year ago patient felt pain in left side and afterwards, due to curiosity, would feel his side and had pain on pressure. Later he felt a mass in the left side, which has continued to enlarge until its contour can be seen on inspection.

Physical Examination.—A large mass in the left upper quadrant of the abdomen which is painful to pressure and movable. Large tumor in the left side of the abdomen, clinically hydronephrosis. Large smooth mass extending beyond the median line to the right and continuous with the kidney shadow.

Pneumoperitoneum.—Movement of fluid in the sac visualized. Stone in left ureter just back of the bladder. Probably hydronephrosis.

Diagnosis.—Ureteral calculus.

Operative Findings.—Large retroperitoneal sac containing urine, attached to the lower pole of the left kidney which lay to the right of the median line. Ureter not connected to sac.

Case: Mr. J. H., age twenty-four years.

History.—Patient first noticed swelling of the abdomen accompanied by pain in the small of the back and around the umbilicus, especially at night when lying on his side. During the past week he has had a slight cough and two profuse night sweats.

Physical Examination.—Dullness of both apices posteriorly from the scapula down. Abdominal distention and umbilical hernia present.

Roentgen Examination.—A small amount of fluid in the left pleural cavity posteriorly.

Pneumoperitoneum showed adhesive peritonitis with ascites, probably tuberculous. Only a small amount of gas could be injected as the needle entered a pocket. The patient complained of pain when very little gas had been injected.

Diagnosis.—Tubercular peritonitis.

Case: Mr. P. S., age sixty-eight years.

History.—The patient had the prostate gland removed in 1918 and says stones were imbedded in it. He recovered from this operation and was in good condition for some time. Six months later he began having painful urination and passed large amounts of gravel and had colic pains in the urethra. He passed nearly one hundred stones through the urethra and had some removed from a pocket in the urethra apparently from a dilatation behind a stricture. He has lately noticed severe pain from a few minutes to a half hour after urination.

Pneumoperitoneum.—Patient could not pass catheter because of swollen urethra. One large bladder stone visualized and several smaller ones.

Diagnosis.—Recurrent stones in the bladder. Proved at operation.

Case: Mrs. C. E. R., age thirty-seven years.

History.—Three years previous the patient had a lump removed from the right breast and one year later a second operation was performed. She has been having attacks of pain in the right side for several years which she thought were pleurisy. The past two weeks she has been getting short of breath but has very little pain.

Physical Examination.—Left pleura markedly thickened. Friction rub on the right side at the junction of the sternum. Breath sounds diminished over the entire left chest.

Roentgen Examination.—Fibrosis with calcified glands extending well out in the right lung. Free excursion of the diaphragm, on the right side. The left lung is radiopaque below the level of the third rib anteriorly. Several round shadows one half inch in diameter are seen in both upper lobes.

Pneumoperitoneum.—Effusion of the left chest. Fluid in the peritoneal cavity which is easily demonstrated. No adhesions, no carcinoma masses demonstrable.

Diagnosis.—Peritoneal tuberculosis.

THE USE OF CO_2 IN PNEUMOPERITONEUM*

By WALTER C. ALVAREZ, M.D.

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SAN FRANCISCO, CALIFORNIA

A YEAR ago, when I began experimenting with pneumoperitoneum, it seemed to me that it would never come into general use unless some way were found of relieving the patient's discomfort immediately after the exposures were made. I felt that the technique would have to be modified in some way so that we could do the work in the office and not in the hospital. Some studies on the absorption of gas from the intestinal cavity had made me acquainted with the fact that CO_2 is absorbed much more rapidly than oxygen. In July, 1919, Dr. Taylor and I injected the preitoneal cavities of a number of rabbits with CO_2 and found that it was absorbed in a few minutes. After convincing ourselves that this gas was as harmless as oxygen we started using it on patients in the office. We found that whereas oxygen often remains in the abdomen in sufficient amounts to cause distress for four days after injection, the CO_2 in no instance remained over half an hour. Ordinarily the patient was relieved of tension in twenty-five minutes.

Dr. Stewart has stated in a recent article that he has tried to make the procedure suitable for office practice by withdrawing the gas through a trocar after the plates are taken. My experience with these patients makes me very doubtful whether many of them would be willing to submit to a second puncture while they are in pain. Moreover, I would rather not make another wound, although my experience with patients who have been operated upon after inflation is in accordance with that of others who have found no sign of damage. In only one case did I see a light strand of omentum adhering to the scar. Another objection to deflation is that it is hard to get all the gas out, and unless this is done completely the patient is going to remain uneasy.

TECHNIQUE

The introduction of the gas is simplicity itself. I use as a measuring bag the rubber cuff that comes with a sphygmomanometer. This holds about a liter. It is connected with the CO_2 tank and with the needle. The air in the tubing should be washed out with CO_2 because the nitrogen in it will remain in the abdomen for 10 days or more. No attempt need be made to sterilize the gas. The needle is sterilized and then thrust through a small spot which has been painted with iodine. I think there is no need for using novocain unless a very large trocar is employed. I use a needle with a caliber slightly larger than that of a lumbar puncture needle. I always clear it first by injecting a few drops of sterile salt solution. The injection is made generally at a point in the middle of the left rectus near the navel. I find it hard to get the patients to take enough of the gas. It is easy with old women who have lost weight and who have flaccid abdominal walls, but it is very hard with muscular men. I make it a routine to give a quarter of a grain of morphin a half hour before the injection. This unfortunately often produces nausea and vomiting later, but it seems the lesser of two evils because one never can tell which patients are going to complain bitterly. Even with the morphin, some do complain of pain, particularly in the right shoulder. Others do not complain of much pain but break out into a cold sweat and seem to be greatly distressed mentally. Others again have paid very little attention to the procedure, and one man got off the table and went out to lunch with me.

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

I think the best evidence that the operation is not a terrible one is the fact that two of my patients, who did not take quite enough gas the first time, volunteered to have the work repeated.

The only disadvantage that I can see to the CO_2 technique is that one must work rapidly if a number of plates are to be secured. We almost always take first a 14 x 17 plate with the patient lying prone. This is developed immediately so that any special points of interest can be focused on in other plates. It is very helpful when the patient has not much gas in his abdomen to rotate him slightly so that the right side is a little higher for the gall-bladder plates and the left side a little higher for the spleen plates. In this way one makes the most of the gas that is there.

I made a few attempts to use mixtures of oxygen and CO_2, hoping that I might slow down the deflation somewhat, but I promptly gave this up because all the disadvantages of oxygen were retained without sufficient compensatory advantages from the CO_2.

Just a word as to the usefulness of the method. If it were not for the distress to the patient one would like to have a set of these beautiful and instructive plates on every individual who comes with intra-abdominal troubles. Unfortunately, however, the procedure is so alarming and distressing to many patients that I do not believe it can ever be used as a routine. I have found it of most help in the diagnosis of gall-bladder disease, especially in the early stages. I believe that daily we are slipping up on the diagnosis of early cholecystitis. We should be helping these people before they develop more definite symptoms, before they get stones and before they suffer irreparable damage to the liver and pancreas. One of the remarkable things about this technique is that it opens up a clear space between the liver and the kidney. Normally, the bowel should drop down out of this space; and in a number of cases in which it did not do that, operation showed the expected adhesions and the expected gall-bladder disease.

In this way I have been able to help a number of women who otherwise would have gone on suffering, because I would not have had the courage to advise operation in the absence of most of the classical signs of cholecystitis. Although some of the thickened gall-bladders without stones show up very clearly on these plates, it is most disappointing that others do not. I have here to-day a plate which fails to show any gall-bladder shadow although it does show a stone which gave symptoms for twenty-five years. To be sure, operation showed that the wall of the gall-bladder in this case was still thin. Moreover, in spite of repeated attacks of inflammation there were no adhesions to the colon. In other cases it was hard to be sure of the disease in the gall-bladder, even at operation. The wall was not definitely thickened, the bile was sterile, there were only a few adhesions to the duodenum and a large gland on the cystic duct. Nevertheless the pathologist reported small abscesses, full of bacteria, and the patient got well after the cholecystectomy. I think these observations must keep us humble, and must make us admit that the roentgen ray diagnosis of early cholecystitis will often be impossible and always difficult and uncertain.

In spite of these disappointments I still feel that the gas technique is going to be very useful. When the history and other findings point strongly to cholecystitis, and when a series of plates, taken in the usual way, leave the question undecided, I practically always resort now to this technique and often get a definite answer. For a while, after discovering the value of CO_2, I kept using O_2 for special cases; but the differences in the distress of the two groups of patients was so pronounced that I finally gave up the use of oxygen entirely. I think that others who compare the after effects of the two gases will come to the same conclusion, and that the use of CO_2 will win out, unless some one can find another gas which is absorbed in perhaps forty minutes. Even then, CO_2 might remain the gas of choice because it is cheap and a common article of commerce.

TRAUMATIC PNEUMOCRANIUM

By ALFRED S. DOYLE, M.D.

Assistant Roentgenologist, University Hospital. Roentgenologist to St. Agnes Hospital and St. Edmond's Home for Crippled Children

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THE subject of traumatic pneumocranium is interesting inasmuch as only a few cases of this condition appear to have found their way into medical literature within the past decade. In THE AMERICAN JOURNAL OF ROENTGENOLOGY of December, 1913, Dr. W. H. Stewart of New York published what appears to be the first recognized case of abnormal intercranial air following fracture of the skull. It is interesting to note that while in the case reported by Dr. Stewart the air was on the right side and in the case which I am now reporting the air was on the left side, the condition was not suspected clinically in either case. In August, 1918, Dr. George W. Holmes of Boston published his case of air in the cranial cavity, and referred in his article to the cases reported by Dr. E. H. Skinner, Dr. W. H. Luckett, and one, not reported, by Walter Dodd.

In January, 1919, Dr. Hollis E. Potter of Chicago published a case in THE AMERICAN JOURNAL OF ROENTGENOLOGY and up to the present time that seems to be the only one on record in which the patient appears to have made a recovery either with or without surgical intervention. It is possible, however, that many cases of this condition presenting no clinical symptoms which would cause the patient to have an x-ray examination have passed unrecognized and made a complete recovery. The indication for operation would seem to depend entirely upon the symptoms, as is shown by the recovery of the case reported by Dr. Potter, in which the patient made a complete recovery without surgical interference, but at no time presented serious symptoms, and showed absorption taking place in subsequent exam-

FIG. 1. LATERAL VIEW OF THE LEFT SIDE OF HEAD, showing air in cranial cavity displacing anterior portion of left hemisphere. The lines of the depressed fracture in the left frontal and temporal region are also shown extending down to the base. Note that the fracture does not show well through the air cavity, because of the over exposure in this area.

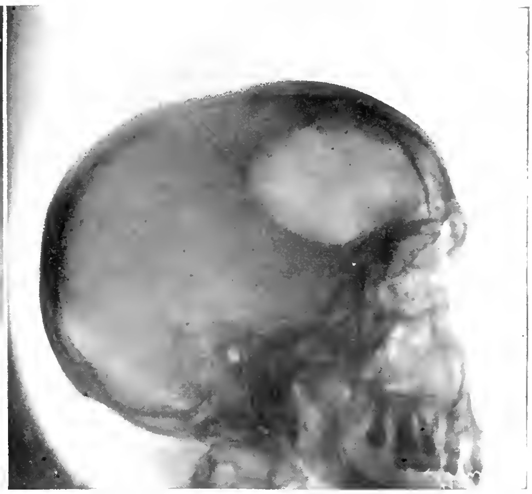

FIG. 2. LATERAL VIEW OF RIGHT SIDE. There is no difference in size of the cavity, as it extends to the midline of the skull.

inations. In our case the patient presented symptoms which progressively grew worse until serious damage had been done to the frontal lobe of the brain and surgical intervention was evidently too late to save the patient. I have been unable to find any cases other than those referred to above with the exception of one reported by Dr. R. J. May of Cleveland and in The American Journal of Roentgenology of April, 1919, in which case the plates were made several hours after death. The condition is somewhat unique in so far as it is not recognized or suspected until after the roentgen examination is made.

On June 7, 1919, the patient was struck by an automobile, at which time he received lacerations of the scalp in the supra-orbital region. He became unconscious and remained so for several days, and then regained consciousness, but complained of constant and severe headache in the left frontal region. He also complained of blindness in the left eye. The left eyeball was slightly sunken in the orbit. No operation was performed at the time beyond sewing up the wound. About the middle of August he became very irritable, but did not attempt violence either to himself or others. He also began to suffer from attacks of vertigo, and would faint three or four times a day.

About the latter part of August his mental condition became worse, and he developed auditory aphasia. When addressed he would frequently give a totally irrelevant reply. This condition became worse. His memory did not seem to be affected, for he had no difficulty in naming his nine children, stating their ages, dates of birth and death, and he seemed to be quite familiar with his circumstances and surroundings, and talked intelligently on topics of every-day interest. For some weeks previous to his admission to the wards of the University Hospital he would wet and soil his clothing, and claimed that he had no knowledge of having done so. He had evidently lost control over his bladder and rectal reflexes. His appetite was not affected and he slept well.

The patient was referred for roentgen examination September 2, 1919, and during the absence of Dr. Pancoast was examined by me. Stereoscopic plates were made of both sides of the head, also one postero-anterior of the frontal region, and one antero-posterior of the occipital region. The examination was made presumably to demonstrate a depressed fracture, which was found in the left frontal and temporal region. We were much surprised to find in addition a large air cavity. The plates of the left side (Fig. 1) showed the fracture involving the lower anterior section. The air cavity was oval in shape with irregular edges and measured 3½ by 2½ inches on the left side plate and about 2¼ inches in width on the plate made of the frontal region. (Fig. 3.)

Difficulty was encountered in obtaining the consent of relatives for the necessary operation; valuable time was lost, the patient gradually grew weaker, and the symptoms became more pronounced. Consent was finally obtained and operation performed September 24th. The skull was trephined in the left fronto-temporal region. The dura seemed tense and under pressure and upon opening it air rushed out with a hissing sound. It was found that the frontal lobe in this region was compressed by the confined air and the brain tissue was soft and lacked its normal resiliency. There was practically no bleeding and no evidence of previous hemorrhage. The dura was freed as far as possible from the skull to permit it to collapse and prevent the reforming of the air cavity. The condition of the patient rapidly grew worse and he died the next day.

The autopsy revealed two openings through the dura and a depressed fracture above the outer half of the orbit extending over to the temporal region in one direction and towards the cribriform plate of the ethmoid in the other. The brain tissue in the affected area was soft and did not expand after the air pressure had been released at operation. Brain tissue was adherent over the frontal sinus but no opening directly into

the frontal sinus was found. The dura was adherent to the skull in many places, and the air was under the dura. The fracture extended into the ethmoid sinuses, into which a probe was passed, and found a free passage into the nasal cavity on the left side. Considerable thick mucous was found in the passage through which the probe passed. This probably acted as a valve in admitting and confining the air.

The unusual features of this case were: (1) The length of time the patient lived with gradually increasing air cavity into which air constantly gained admission from the ethmoid cells and could not escape. (2) The condition was not suspected.

FIG. 3. POSTERO-ANTERIOR VIEW, PLATE ANTERIOR, showing the lateral dimensions of the air cavity.

FIG. 4. ANTERO-POSTERIOR VIEW, PLATE POSTERIOR, showing limitation to left hemisphere.

A RETINOMETER*

By A. HOWARD PIRIE, M.D.

MONTREAL, CANADA

THE instrument which I present to you was made in order to allow me to test the sensitiveness of my own retina to the fluorescent screen. I use it for this purpose from time to time, but its chief field of usefulness is in its power to take up the attention of visiting physicians and surgeons who come to the fluoroscope with retinae rendered most insensitive by the light in which they are accustomed to work. These visitors to the fluoroscope are invariably willing to go on using the retinometer till they are ready to see the fluorescent screen to advantage. The more visitors who come at one time the better, as then there is competition between them as to who will first develop sufficient sensitiveness of his retina to be the first to use the instrument.

The retinometer consists of three luminous discs, the largest is a triangle, the medium sized one is oval and the smallest one is a circle with a diameter of about 1 mm. These three discs are kept in the dark by a covering flap which is kept in apposition

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

with the discs by means of a spring. A string a yard long is attached to the flap. By pulling this string the discs are exposed. The free end of the string has a luminous tassel for the convenience of finding it in the dark. To use the instrument the observer picks up the tassel and pulls on the string; holding the tassel in his hand, keeping the string taut he

Fig. 1. Retinometer Closed.

places the tassel against his temple, his eyes are then at a distance of one yard from the instrument and the luminous discs are exposed to his view. He is now in a position to gauge the sensitiveness of his retinae. Most observers are able to see the luminous tassel at once. One who has come into the dark room from out of doors will be unable to see the large luminous triangle. But by going close up to it he will see it and he can then recede from it gradually, keeping it in view as his retina grows more sensitive. When he can just see the large triangle alone at the distance of the length of the string (one yard) he will be unable to see the next brightest spot—the oval, but by now going close up to it he will be able to see the oval and by the time he can see the oval at the distance of the length of the string, he is ready to begin to use the fluorescent screen. Until he can see the triangle and the oval in the dark his eyes are not in a fit state to look at the screen. It is folly to point out tuberculosis to a visiting physician when his eyes are not sensitive enough to see these two discs in the dark. Visitors to the dark room seldom stay long enough to be able to see the third luminous disc, but the radiologist should be able to see it plainly himself.

When finished with the instrument the observer lets go of the string and it automatically closes, thus protecting the luminous discs from the action of light. The discs shine more brightly in the dark after being

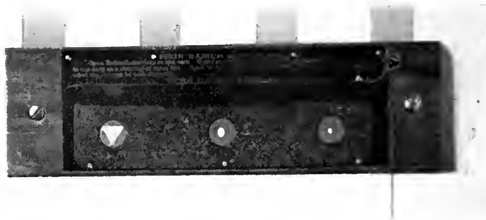

Fig. 2. Retinometer Open.

exposed to bright light and for this reason they are always kept in the dark and only exposed to view by the action of pulling the string. They remain of constant luminous power if they are not exposed to the light.

The three discs chosen for this instrument

Fig. 3. Retinometer in Operation.

are the standard discs of a company manufacturing them. I picked them out of a large selection of standard luminous discs, and have been using them for more than six months during which I have noticed no change in the power of their luminosity.

I have to acknowledge the help of the Victor Electric Corporation in getting the instrument up in its present shape, which differs considerably from my first model.

INTRACRANIAL CALCIFICATION*

By JOHN T. MURPHY, M.D.

TOLEDO, OHIO

THIS paper is the result of an interest in the subject aroused by the following case:

CASE REPORT

Mrs. M. J. L. Referred by Dr. Pamment. Occupation: Bookkeeper. Age forty-seven. Married.

Previous History.—Negative except for diphtheria in childhood. Perineal repair in 1912. Menstruation began at eighteen years. Stopped at the age of forty-two. Always regular and no pain. Patient married at twenty-four years and had her first child at twenty-seven years, which died fourteen months later of infantile paralysis.

Convulsions began some time after an operation for repair of a perineal tear, in 1912. At first they occurred about twice a year, then four times a year and during November, 1919, she had four. With two exceptions they always came on during sleep. Her husband states that he would be awakened in the early morning by her moaning and would find her shivering, teeth set and some frothing at the mouth. She would be unconscious of the attack until the next morning, when she would find that she had passed her urine in the bed, and had a sore tongue and a severe headache. She would feel so tired and muscle sore that she would not go to work that day. She has had more or less headache, but noticed that the headache was very severe and continuous the whole month of November, 1919. Has had no nausea or vomiting. Has worn glasses for some time but has not noticed that her eyesight was getting worse previous to this last attack.

Present Complaint.

1. Paralysis of right arm and leg.
2. Inability to speak.
3. Drooling from right side of the mouth.
4. Convulsions.
5. Headache.

History of Present Complaint.—On Nov. 29, 1919, patient got up at the usual time, dressed herself and went to the kitchen to prepare breakfast, but was not conscious of it. Her husband saw that she was not well and insisted that she go back to bed. He tried to have her drink some coffee but she couldn't hold the cup. He put her to bed where she slept almost continuously for twenty-four hours.

Physical Examination.—Nov. 30, 1919. Patient is a robust woman, lying in bed, conscious but unable to talk. Head and Neck: Right side of face is smoothed out. Tongue protrudes to the right. Mouth is drawn to left. Drools out of right side of mouth. Right eyelid closes partly only. Patient tries to talk but cannot. Chest: Lungs—negative. Heart: Borders normal, rate, 70, rhythm good. No murmurs. Abdomen: Negative. Right Arm: Can move it part way to head. Left Arm: Normal. Right Leg: Can move it slightly. Left Leg: Normal. Blood Pressure: Systolic, 130; Diastolic, 85. Blood Wassermann: Negative. Spinal Fluid: Negative. Urine: Negative.

Since this time there has been a gradual return of normal functions. No convulsions since onset. As soon as the patient was able to be about she was brought in for examination with the *x*-rays. A stereoscopic set of plates showed the following:

A series of fine calcified lines, each forming part of a circle, was seen to lie above and behind the sella and about midway between the left side of the skull and the median line, the whole making a barrel shaped shadow with the long diameter transverse, size about ½ inch in width by about ⅝ inches long. There is also a distinct increase in the markings of the frontal bones on that side.

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

On reviewing the literature an exhaustive study of the subject was found in the *Johns Hopkins Hospital Bulletin* for October, 1916, in which the entire subject of the use of the *x*-ray in brain tumor cases was taken up. The previously reported cases are reviewed. They are seven in number, all from the foreign literature. To these are added six of their own, found in a series of 100 cases clinically demonstrated brain tumors.

calcification extended from the base upward into the brain substance, one case of aneurysm of the internal carotid artery, and two cases of calcification above and very close to the sella.

In The American Journal of Roentgenology, 1916, iii, is a report of a case by A. W. George, as follows: A man twenty-three years old. Stereoscopic plates of the head made in the lateral position show an

Fig. 1. Showing Calcareous Mass in Left Side of Skull.

area of about 3 cm. in diameter, posterior to the sella, with apparently calcified walls. The patient had been injured in the head while playing football and was unconscious. Epileptic attacks began about eighteen months ago. Operation showed a small tumor situated just below the pia mater and adherent to the midfrontal lobe, diagnosed as an encapsulated glioma.

In the cases reported in the foreign literature Fittig observed three calcified areas in the walls of a cyst in an occipital lobe; Grunmach a calcified tumor in the pineal gland; Algygi a basal tumor with areas of calcification; Klineberger a tumor of the occipito-parietal region; Steida a calcified cysticercus, and Sträter a calcified brain abscess only recognized after operation; Lichtheim a calcified gumma also not recognized until after operation. Schüller in his book reports five cases all of which are calcified areas in the brain substance itself. Huerig and Dandy's cases are as follows: One case of calcification of the brain substance, one case of calcification in the sella, one case of

In an endeavor to find out the general experience of roentgenologists, I wrote to twenty-five of the members of the Society, asking them to give me their experience with the demonstration of calcified areas within the skull. Many of the letters spoke of the calcification of the pineal gland, which was

considered as a normal finding. Except in four instances the replies were negative for other findings. Dr. Charles F. Bowen reported one positive case in approximately 200 cases examined. The history is as follows:

There was a calcareous deposit about 1 inch long and ½ inch wide which was found to be lying just above the external auditory canal about 1 inch from the inner table. It was lying in the brain tissue. This was removed at operation and his epilepsy cured. The man had had a fractured skull about fifteen years before. Dr. Bowen was of the opinion that a small piece of bone was driven into the brain tissue acting as a nucleus for the deposit of lime. The specimen however failed to show any nucleus of this kind. This was the only case in the experience of these men in which they were able to show calcification in the brain itself. One man had had considerable experience with calcified areas in the falx cerebri, the "psammoma" of the textbooks. Two other men called attention to the finding of calcified plaques in the meninges. Other than this the findings had all been negative.

The actual diagnosis of the case I have reported is in no way clear to me. Whether it is a cyst of the brain or an aneurysm of the anterior cerebral artery I am not sure. It is however clear from the clinical view-point that its presence has at times caused changes in the internal capsule; the absence of general signs of pressure is noticeable, and although the eyegrounds were not examined at the time of the paralysis, later examination shows them to be clear.

Roentgenograms made recently of the case seem to show that the tumor is less clearly defined; this however may be due only to difference of technique. The fact that the patient has been on small doses of the iodides continuously since, may have had some effect. She now is apparently in good health, with no headaches and only a small facial paralysis remaining.

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DISCUSSION

Dr. W. F. Manges. I know but little about the subject of the author's paper. I have seen quite a number of calcified masses in the skull. I have not come to the point where I want to take the time to study the literature on the subject, and unfortunately the cases are so seldom operated, that we really don't get to the final diagnosis in the matter.

I have recently had a case in which there was a calcareous mass that was fully an inch and a half in length and practically an inch in its greatest width, irregular in outline, and very much more densely calcareous than is shown in Dr. Murphy's case. This particular patient had no symptoms whatever, except headache. He was a clothing salesman, who had been working up to within two or three days of the time when I first examined him, but he did have at that time very violent headache. He stayed around the Hospital for a while, and became dissatisfied about something and went elsewhere. Finally someone started giving him iodides—his Wassermann had been negative both by blood and spinal fluid—but with iodides his headache disappeared, and he was apparently very much improved. I haven't had a recent radiograph of him, so I can not say whether or not there has been any change in the tumor.

In another instance, an adult, man, age forty-five to forty-eight years, had been perfectly healthy all his life, without any history

of injury until just shortly before my examination—I have, I believe, shown this case before this Society or some section of it previously—and the radiographs of the head showed a dense "stone," I called it, in his brain, within about a half inch of the cortex on one side. He came to me for examination because he had recently developed epileptic convulsions, never having had any during early life, and no family history of anything of the sort. What the origin of that density was, I haven't the faintest idea, but I think the injury he received shortly before he came to me was severe enough, and the weight of this thing sufficient, that the trauma that otherwise would not have been disastrous at all, set up an irritation which was the cause of his epilepsy. He refused operation.

Then again I have had a number of cases in which these calcareous nodules were multiple and scattered throughout the brain, near the cortex, and deep in the brain, and in only one instance did I have any idea as to what the cause might be, and that was the case of a child who gave a very definite history of tuberculous meningitis, and I thought perhaps there had been foci of infection in the brain at one time which had healed by calcareous deposit.

Dr. W. A. Evans. We have been able to classify intracranial calcifications under three general heads. The first is the calcification which occurs in cyst walls. These cysts have been observed both in infancy and adult life. Infants showing calcified cyst formation usually present evidence of impaired mental development or a spastic paraplegia. The calcifications occurring in adult skulls are usually associated with cysts which are secondary to a fracture of the skull or subdural hemorrhages. Plates of the head in a case recently referred for skull examination, with a history of epilepsy, revealed a calcification which occurred in the brain substance, the distribution of lime suggesting deep brain cyst.

Under the second heading are the deposits of so-called "brain sand." Of special interest at this time is the deposit of lime in the pineal body, it being claimed by some observers that the calcification of the pineal is evidence of its degeneration, with resulting loss of function; accordingly cases presenting abnormal sexual development should present atypical calcifications of the pineal gland. In our experience, there has been no constant connection between early deposits of lime in the pineal gland and precocious sexual development of thirteen, in which we were unable to show any brain sand in the vicinity of the pineal.

The deposits of brain sand in the falx cerebri, the so-called psammoma, should not be considered as the same type as a pineal calcification. Some pathologists classify them as a true bone tumor or osteoma.

Under the third heading, and this is probably the least important, is the calcium deposit in the walls of the blood vessels, especially the circle of Willis.

NEW ROENTGENOGRAPHIC TECHNIQUE FOR THE STUDY OF THE THYROID*

By GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

MY experience in the study of the thyroid roentgenographically, heretofore, has been generally unsatisfactory. I have seen no description of technique that really demonstrates the outline of the thyroid except in very large thyroids or in the large substernal thyroids. These have been studied in the postero-anterior position, especially by Drs. Crotti and Bowen in their excellent paper presented before this Society in 1913.[1]

FIG. 1. P.24454-D. MR. J. S. CARCINOMA OF THE THYROID. Note the size of the thyroid, but particularly the irregular compression of the esophagus.

Since so large a number of the hyperthyroid cases are sent for roentgenotherapy, because of the excellent therapeutic results obtained in the treatment of toxic goiters, we have an excellent opportunity for a careful study of this group of patients. Therefore, in February of this year I determined to investigate these cases as thoroughly as possible roentgenographically, and have finally developed a technique that is almost universally satisfactory, because one can, by this method, demonstrate not only the abnormal thyroid and the enlarged thyroid, but the normal thyroid. I know of no other technique which will demonstrate the size and outline of the normal thyroid.

It is well known that the reduction in the thyroid by roentgenotherapy is one of the latest results obtained in the treatment of the exophthalmic goiters, or Grave's disease. I have many patients that have been cured, but unfortunately I do not have their original roentgenograms; that is, the roentgenograms made of their particular cases at the beginning of treatment. I am quite sure, however, that as this study is further developed and continued, we can record quite accurately the progressive reduction in the size of the goiter. Measurement of the circumference of the neck in determining the reduction of the goiter is very crude, for one may actually have a reduction in the size of the tumor, and yet an increase in the size of the neck, because it is quite well known that as exophthalmic goiter cases improve, they begin to take on weight. In fact, increase in weight is one of the earliest signs of improvement. As they increase in weight, naturally the circumference of the neck increases due to the deposit of fat, and therefore the goiter may be reduced while the circumference of the neck shows very little reduction or even shows an increase. It cannot, therefore, be depended upon as a method of recording the progressive reduction of a goiter.

[1] CROTTI, ANDRE. The roentgen ray in intrathoracic goiter and thymus hyperplasia. *J. Am. M. Assn.*, Jan. 11, 1913, p. 117.

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

In a number of cases patients are sent with symptoms of hyperthyroidism and one can feel little or no enlargement of the thyroid, but since I have been using this method of recording, I have not found one in which there was not an actual enlargement of the thyroid. I cannot say, however, that one does not have hyperthyroidism without an increase in the size of the thyroid. Occasionally a patient complains of difficulty in swallowing due to pressure in the region of the thyroid and yet, by palpation, the enlargement is so slight (or entirely absent), that it is difficult to understand how a patient can have such symptoms without palpable enlargement. By this method, however, compression of the trachea or pressure of the esophagus can be shown and these symptoms explained. It is well known that even the very large goiters may cause no pressure effects on either the trachea or the esophagus. On the other hand, a very small goiter or small adenoma may press posteriorly and cause a very distinct symptom of pressure and difficulty in swallowing or breathing without being palpable.

This method may be of value in differentiating malignant goiter from the benign goiter—probably only in occasional instances, however. In one case there was considerable irregularity in the outline of pressure upon the esophagus.

Fig. 2. P.29437-D. Moderate-Sized Goiter Showing Marked Compression of the Esophagus.

Fig. 3. P.28929-D. Note the Compression of the Esophagus by a very small Goiter in a Case in which the Goiter was not Palpable. Note the enlarged lymphatic gland under the angle of the jaw.

TECHNIQUE

The examination is made with the patient in the standing posture. The position best showing the outline of the tumor is obtained fluoroscopically. The patient's sternum and the anterior portion of the neck is pressed strongly against the fluorescent screen. The chin is turned toward the side on which the enlargement is most marked and tilted upward as far as possible. This draws the thyroid up into position where it can be shown in the plate. One's aim must be to get a good lateral view of the neck, but both shoulders should be as nearly as possible in contact

with the plate. I think it is entirely possible that this same technique can be carried out with the patient lying down upon the table; but in my own laboratory I have found the above position more practical. The tube plate distance is 25 inches. The tube is centered midway between the lower border of the jaw and the upper border of the clavicle and centered directly over the thyroid. I use 8 by 10 duplitized films and double intensifying screens. The exposure will vary from three-fourths to one and a quarter seconds, depending upon the thickness of the patient's neck, with 35 milliamperes, and a 5 inch spark-gap.

With the above technique it is possible and advisable to examine every goiter patient that comes to the office, making a definite record at the beginning of treatment, and making further records during the treatment or at the end of treatment. Further use of this method of examination and detailed study will probably demonstrate more clearly its usefulness.

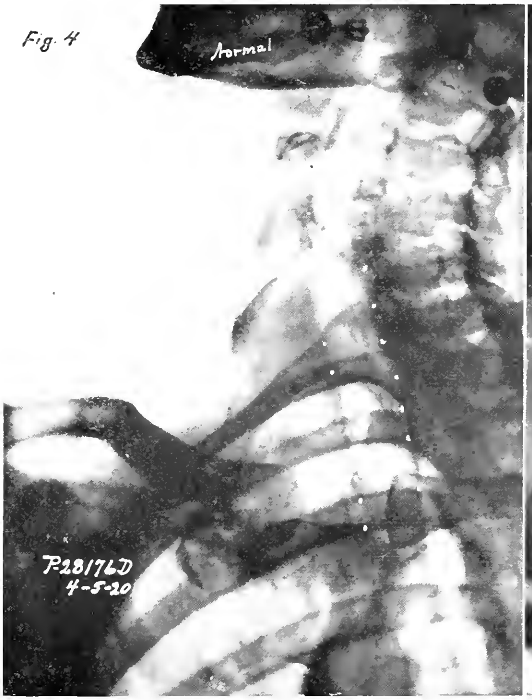

Fig. 4. P.28176-D. Normal Thyroid. Note the Smooth Outline of the Esophagus, and the size of the Thyroid.

Fig. 5. P.28060-D. Showing Normal Thyroid in a Patient that had been Cured of Exophthalmic Goiter.

DISCUSSION

Dr. L. Jaches. I would like to ask Dr. Pfahler to describe the position again. I did not quite get it.

Dr. P. M. Hickey. I was about to ask the same question. I did not quite get the angle. I thought perhaps he would again demonstrate the exact technique.

Dr. B. C. Darling. I would like to ask Dr. Pfahler if there is any possibility of confusing the sternocleidomastoid muscle in that position with the shadow of the thyroid.

Dr. G. E. Pfahler (closing). Answering Dr. Darling's question, if you study those plates carefully, you can see the sternocleidomastoid and why it would not be confused with the shadow of the thyroid. It was shown in a number of the normal cases. If you recognize the normal, it is easy to recognize the abnormal by comparison. I merely present this as a method and not as a final study. (Position again demonstrated by Dr. Pfahler, with Dr. Bowman as subject.)

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ANNUAL MEETING CENTRAL SECTION

The Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY will be held on February 21, 1921, at St. Louis, Missouri.

Communications regarding the program should be addressed to the president, Dr. James G. Van Zwaluwenburg, Ann Arbor, Michigan. The chairman of the local committee, Dr. Edwin C. Ernst, 412 Humbolt Building, St. Louis, may be addressed concerning matters of arrangements.

ANNUAL MEETING WESTERN SECTION

The officers of the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY are making plans for their second annual meeting. They have selected Portland, Oregon, as the place of meeting, and the time has been set for May 27th and 28th. This time will permit of a continuous trip for the western men who desire also to attend the A. M. A. meeting in Boston.

The Pacific Coast Roentgen Ray Society will meet at the same time and place, the two organizations being the guests of the Portland Roentgen Club, a very active organization of specialists.

The Secretary of the Western Section would welcome a visitor or two from the East with papers or demonstrations, and can assure them of a very enjoyable meeting. Address Dr. Warner Watkins, Box 1328, Phoenix, Arizona.

LAWRENCE HERSCHEL HARRIS

Lawrence Herschel Harris died at his home in Sydney on September 13, 1920,

LAWRENCE HERSCHELL HARRIS

after a distressing illness of fifteen weeks due to an encephalitis following influenza. He was the last of Australia's pioneer roentgenologists, having taken up this specialty in the late nineties. He was appointed roentgenologist to Sydney Hospital in 1900, and at the time of his death he was consultant to this hospital and also director of departments of Roentgenology at the Royal Prince Alfred and Royal Alexandra Hospital for Children in Sydney. He was made an Honorary Member of the AMERICAN ROENTGEN RAY SOCIETY in 1916 and was President of the Section of Roentgenology at the Australasian Medical Congress in 1913. He was visiting England in August, 1914, and volunteering immediately left London on August 16th with the Australian Voluntary Hospital for France. Later he was transferred to No. 3 A. G. H. at Lemnos, and after the evacuation of Gallipoli he was invalided to England on account of his dermatitis growing worse.

For many years he had suffered patiently with his hands. This did not affect his uncommonly genial and courteous manner which endeared him to the profession and patients alike.

He was the first man in Australia to do gastro-intestinal work, and as in everything else the standard he set was of the highest. He was always found to be most willing to give others the benefit of his experience. All roentgenologists in Australia owe a very great deal to one whose charming personality and high professional attainment will live long with all, while to the large circle of those more privileged to have known him as a friend, the memory of that kind, generous and true white man will be theirs always.

L. J. CLENDINNEN.

TWENTY-FIFTH ANNIVERSARY OF THE DISCOVERY OF THE X-RAY

The New York Roentgen Society celebrated the twenty-fifth anniversary of the discovery of the *x*-ray on December 11, 1920.

The celebration was held at the New York Athletic Club, New York City, and took the form of a dinner with members of the Philadelphia and New England Roentgen Societies as guests. Fifty-two members and guests were present, with Dr. H. M. Imboden, President of the New York Society, acting as Toastmaster.

Following the dinner Dr. Percy Brown of Boston proposed a silent toast to those former members of the Societies who had lost their lives as martyrs to the advance of roentgenological science.

Prof. J. S. Shearer, speaking on "*X*-Ray and Research," drew attention to the large part that branch has played in the discovery of electrical science and especially of that branch with which roentgenologists are concerned.

Dr. F. H. Baetjer in discussing "*X*-Ray Diagnosis, Its History and Present Status," recounted delightful reminiscences of the early days of the work at Johns Hopkins University in the late 90's and early part of the present century.

Dr. C. W. Holmes followed with some remarks on the present status of *x*-ray therapeutics, and the evening was closed by Dr. W. D. Witherbee, who presented a "Preliminary Report on the Effect of *X*-Ray upon Tonsillar Tissue."

CHARLES EASTMOND.

REPORT OF COMMITTEE ON TEACHING

In recommending a course in roentgenology for undergraduate medical students your committee finds that it is not an easy task to determine just what is the proper amount of instruction to meet the actual needs of the medical or surgical practitioner without loading him with a mass of interesting but technical information that he cannot use.

In determining an ideal course, the question that first arises is whether it is advisable to crowd into a curriculum already more than full, another separate course, when it is so intimately bound up in nearly every other subject of the curriculum that hardly can any branch be properly taught without dealing with its roentgenologic aspects. Does a student then acquire in the other courses

a sufficient knowledge of the subject to be able to read and intelligently digest the roentgenologic reports and illustrations in an article or lecture that has a roentgenologic aspect? Your committee finds that there are two extremes with perhaps as cogent reasons for one view as for the other. One of these holds that roentgenology is a specialty for those trained therein and that the medical or surgical specialist be given only the results of his investigations. This same argument would apply with equal force to the pathologist and clinical diagnostician. Who would have the temerity to advocate leaving these two subjects to the mercy of the teachers of other branches?

The other extreme tends to attempt to make roentgenologists of all medical graduates and thus bury completely the subject as a true speciality. There seems to be a middle ground that can safely be adopted, one that will acquaint the student with the scope and usefulness of the agent, enable him to know when to call in the services of the roentgenologist, how to prepare patients for the exination, to understand the reports that are submitted, and to know how and why the conclusions have been reached—all this without any practical knowledge of handling the apparatus or any of the technique employed.

Your committee therefore submits the following as a fair minimum of instruction to accomplish the ends that appear to be desired:

(a) That the subject be taught preferably in the junior and senior years.

(b) That a minimum of forty-two hours be given each student.

(c) That the junior course consist of at least three lectures and demonstrations as a general introduction, and at least twenty-nine lectures and demonstrations dealing with the diagnostic field and therapeutic applications as well as the dangers and methods of preventing injuries.

(d) That the senior course be a minimum of eight hours per student consisting of demonstrations of clinical cases to the sections.

It is especially desirable that the senior students follow their cases to the roentgen ray laboratory, see the examinations made and the findings interpreted and reported.

The committee further recommends that the use of roentgenologic methods be employed to the fullest extent practicable in the teaching of anatomy, physiology and the other fundamental subjects, and that there should be the closest possible cooperation between these departments and the roentgenologist.

A. L. Gray, *Chairman.*
F. S. Bissell
P. M. Hickey
J. S. Shearer
W. F. Manges
Committee on Teaching.

REPORT OF SECOND ANNUAL MEETING EASTERN SECTION

The second annual midwinter meeting of the Eastern Section of The American Roentgen Ray Society was held in Atlantic City January 28th and 29th, in the new Chalfonte-Haddon Hall auditorium, with the president, Dr. David R. Bowen, of Philadelphia, presiding.

In point of attendance this was the largest midwinter meeting ever held, and from the enthusiasm expressed by those in attendance, must be rated as one of the most successful.

The Friday evening session was devoted to diversified subjects on x-ray diagnosis. The Saturday morning session was devoted entirely to subjects involving x-ray physics. The Saturday afternoon session was given over to a symposium on x-ray therapy and a symposium on lung diseases. The Saturday evening session, as is customary, was devoted to the lantern slide exhibit. This exhibit has come to be recognized as the place where most roentgenologists bring their difficult and unusual cases.

The discussion at the morning and afternoon sessions on Saturday developed the feeling that there was need for coordinated physical and pathological research in the

therapy field. Special emphasis was laid upon the necessity for pathological research, the feeling existing that physical research was advancing beyond the pathological. By resolution the President was authorized to appoint a committee to make recommendations to the parent society at its annual meeting as to how this coordinated research could best be done.

The commercial exhibit was an innovation at midwinter meetings. There was a large number of exhibitors and a great deal of interest centered in the new apparatus exhibited.

At the election of officers, held on Saturday evening, Dr. J. M. Steiner of New York was elected president for the ensuing year and Dr. C. A. Waters of Baltimore, was elected secretary. J. M. Steiner, *Sec.*

A CORRECTION

In the January number of the present volume, page 24, there is an article entitled, "Dislocation of the Carpal Scaphoid." The word "scaphoid" is used throughout the article and in the legend. "Scaphoid" is an error, as the condition is evidently a dislocation of the semilunar bone.

BOOK REVIEWS

A. Dauvillier, *Recherches Spectrométrique, sur les Rayons X.* (Thesis presented to the University of Paris.)

This thesis describes the author's experiments on the variation in *x*-ray spectra when various tubes and methods of excitation are employed. It is indeed fortunate that this admirable piece of research has appeared at this time, when such extravagant claims are made for certain types of apparatus. It is clear that we can never have a rational basis for *x*-ray therapy until we know the true distribution of the radiation from the tubes. Without definite knowledge of this kind we are quite unable to decide between various operating devices or to coordinate our work.

Omitting, in a brief review, the technical details of the experiments, the points considered and the conclusions are briefly as follows:

1. What variations in spectral emission of *x*-rays are to be expected with different tubes when operated on various available wave forms?
2. To what degree is the output of short wave lengths influenced by the type of tube and mode of operation?
3. Are the limiting wave lengths observed for different voltages in accord with the predictions of theory?
4. What are the practical indications for therapy?

As regards No. 3 above, the author finds agreement with the theory and determines the displacement of the wave length of maximum ionizing power toward the short wave length portion of the spectrum. He points out that the claims of superpenetration and unusual homogeneity claimed for the Lilienfeld tube are entirely unwarranted from the data at hand, disposing very effectively of the claim that spectral distribution varies with cathode ray concentration.

The practical indications are in entire accord with the views often expressed by those familiar with fundamental physics and who are not misled by experimentation intended to support some preconceived notion or widely advocated method of measurement. The author's statement is as follows:

"The results mentioned permit standardization of *x*-rays, thanks to the Coolidge tube. We propose to replace the present procedures in dosage, empirical and naturally lacking in precision, by some simple direct measurements of tension, intensity of tube current, distance and the duration of exposure. The fundamentals standardized will be:

"1. The type of tube: Tubes of pure electron emission.

"2. The target material: Tungsten.

"3. The wave form of the electromotive force: Sinusoidal or preferably constant. The independent variables will be:

"4. The maximum tension (measured by a voltmeter).

"5. The mean intensity of current.

"6. The nature and thickness of the filter used.

"7. The distance from focus to skin.

"8. The duration of exposure.

These conditions completely characterize the radiation and permit its exact reproduction independent of all spectroscopic measurements."

The author promises further investigation to determine for all workable conditions the actual spectrum distribution.

With such information as to the delivery of radiation from the tube and the recent exact study of absorption coefficients by Richtmyer and Grant we shall be able to eliminate the vagaries and uncertainties that now beset x-ray therapy.

The work of this author and those who supported and encouraged it is not only extremely valuable, but is a splendid example of the true spirit of research. It was carried on as an extra load during the turmoil and strain of the war when so few were even thinking of these unsolved problems.

J. S. Shearer.

TRANSLATIONS & ABSTRACTS

ROBERTS, PERCY WILLARD, New York City. Syphilitic and Tuberculous Joints. (*Am. J. Syphilis,* April, 1920, iv, No. 2, 302.)

During the past four years he has observed over two hundred bone and joint cases which were undoubtedly of luetic origin and which possessed the symptoms usually ascribed to tuberculosis. It is interesting to note that fifty-one of these cases were diagnosed as tuberculosis by twenty-six experienced surgeons and treated on that basis for periods varying from a few months to fifteen years. In some of them there was a positive Wassermann of from one to four plus, and in all of them there was subsidence of active symptoms a few weeks after the exhibition of mercury and potassium iodide. The Treponema pallidum may produce tubercles identical in structure with those in which the tubercle bacillus is found. In both lues and tuberculosis an affected joint will present symptoms of irritation and there will be muscular spasm. In both diseases there may be enlargement of the joint with effusion and the formation of pus, sterile on ordinary culture media. There may be sensitiveness, limp when a weight-bearing joint is involved and alteration of attitude if the disease is vertebral. *X*-rays may show a bone lesion in either disease, but contrary to accepted theories there are usually no definite characteristics upon which to base a diagnosis. "In a series of fifty of the cases the Wassermann reaction was so frequently negative in the face of other evidence of spyhilis and satisfactory therapeutic results that it may be said that in the late manifestations of inherited lues it is only occasionally of value. The duration of the disease bore no relationship to the possibility of treatment. Two knee cases, one of six and the other of ten years' duration, recovered practically normal function, with regeneration of the necrotic bone area. A spine case of fifteen years' duration gained sixteen pounds in ten weeks. Three out of seven profusely discharging sinuses in this case closed completely and the secretion from the others became thin, watery, and of small volume. When the patient passed from observation, he was able to take long walks and was leading a normal life. A hip case of twenty-five years' standing in which almost constant pain had been a predominant symptom, became entirely comfortable in about ten days. His Wassermann was positive. All of these cases had been under continuous treatment for tuberculosis from the onset of their symptoms."

ROHDENBURG, G. L., AND PRIME, FREDERICK. The Effect of Combined Radiation and Heat on Neoplasms. (*Archives of Surgery,* January, 1921, II, No. 1, 128.)

Low degree of heat applied for varying periods of time have a lethal action on neoplastic cells in vitro, and this lethal action with proper dosage is effective in 100 per cent of cases. Histologic examination of tumors which have been treated by diathermy reveals cellular changes similar to those observed in tumors exposed to radiation.

Wood and Prime have shown that any tumor may be killed by a sufficient dosage of either radium or roentgen ray; but that in maiy instances the patient will not survive the dosage necessary to bring about the death of all the cells of an internal, highly malignant carcinoma or sarcoma. Our experiments demonstrate that by combining radiation with an agent not so destructive to the organism the field of usefulness of radiotherapeutic measures may be extended.

While the principles worked out in the animal experiments here recorded are already being applied in the treatment of cases of neoplasia in human beings, the technical development of the method and the evaluation of the final results will require long and careful observation of the patients before its applicability can be demonstrated.

CHASE, SUMNER B. The Roentgen Ray in the Diagnosis of Sinus Disease. (*J. Iowa State Med. Soc.,* December 15, 1920, x, No. 12, 404.)

Two positions are commonly used, the postero-anterior and the lateral, the latter of which is sometimes stereoscoped. The Caldwell position is commonly used for the frontals. One of

the earliest signs of malignancy in the antrum is an even clouding in the plate with a slight break in the outline of the wall. The plate should be carefully examined for signs of teeth such as are found in dentigerous cysts, and if present the alveolar process should be examined for the loss of one or more teeth. These cysts cause bone absorption and not bone destruction. Osteomata present a characteristic appearance of a solid growth, while odontomata show well defined walls enclosing one or more teeth. A giant cell sarcoma presents the usual trabeculated appearance. A malignant growth is differentiated in the plate from the clouding of an empyema or a thickened mucosa by the fact that the bone itself is attacked. The vertical position for the sphenoid examination he regards as important, as by it can be determined the presence or absence of a large posterior ethmoidal cell or a perisphenoidal cell which sometimes lies adjacent to the sphenoid and may simulate disease in this sinus. For instance, the lateral plate will show a cloudy appearance of the sphenoid while the vertical plate will prove this to be a large opaque ethmoid lying adjacent to the sphenoid with the latter clear. It also helps to determine on which side to operate for pituitary tumor by the nasal route because these sinuses are not symmetrical.

A differential diagnosis between polyps and mucocele can not be made definitely although the polyp is more liable to have associated inflammation of the mucous lining of the antrum which would produce a certain amount of clouding of the remaining portion.

He quotes experiments which Caldwell made showing that the shadow cast by various fluids, such as water and pus, was practically the same and that mucous membrane soaked in water casts a much denser shadow than dried mucous membrane.

The roentgen ray is a valuable aid in the diagnosis of accessory nasal sinus conditions Anatomical details of practical surgical and therapeutic importance are shown.

The history, symptoms and clinical findings should be taken into consideration in interpreting the plate.

With properly taken plates, and ruling out previous operative interference, blurring of the margin, or entire extent, of the larger sinuses is interpreted as a pathological condition in the sinuses.

The obliterations of the septa in the small sinuses as the ethmoids, with correctly taken plates and no previous operative interference, indicates pathology present.

The roentgenogram of the sphenoidal sinus as to the condition of the lining of the sinuses is still unsatisfactory.

In certain conditions the diagnosis of the pathology present may be made by the *x*-ray alone.

Pathology is very rarely found in sinuses that appear absolutely normal in the roentgenogram, although it is possible in early acute cases to have pus present with practically no shadow shown in the plate; and all clinical means of examination should be used.

Steindler, Arthur. Congenital Malformations and Deformities of the Hand. (*J. Orthopedic Surg.*, November, 1920, ii, No. 12, 639.)

This very interesting paper is enhanced by the following classifications:

A. Deformities by developmental suppression, agenesis:
1. Congenital Defect of the Forearm Bones.
2. Lobster Claw Hand.
3. Ectro-dactyly (A-phalangism).
4. Hemimelia.

B. By Developmental Arrest.
1. Syndactyly.
2. Sym-phalangism.

C. By Developmental Aberrations.
1. Polydactyly (some cases).
2. Hyper-phalangism.

D. Dysplastic Conditions.
1. Chondro-dystrophy.
2. Brachy-dactyly (some cases).
3. Fusion of carpal bones.

E. Polyglandular Dystrophy.
1. Polydactyly (some cases).
2. Macro-dactyly.
3. Arachno-dactyly (partial gigantism).

F. Contractures (Neurogenetic or amniotic).
1. Contracted Club Hand.
2. Contracted Fingers.
3. Amniotic contractures (non symmetrical).

The author confines himself closely to the discussions of his classifications in the twenty-five case reports which are summarized in the following:

1. Of the 25 cases reported, hereditary tendencies were in evidence in 5 cases, deformities of the hand being found in other members of the family in 3 cases, other deformities or anomalies in 2 instances. Identical deformities in family twice, one case of syndactyly and one case of congenital club hand.

2. Complicating deformities of the extremities were found in 15 cases, among which complicating deformities of the hand 4, namely: Symphalangism in one case of syndactyly; Syndactyly in one case of congenital ulner club hand; Syndactyly in one case of contracted club hand, and syndactyly in one case of lobster claw hand.

3. Complicating deformities of the spine and thorax were found in 3 cases.

Rhachitic deformities of spine and thorax in one case of syndactyly.

Congenital scoliosis with wedge shaped vertebrae in one case of contracted club hand.

Elevation of scapula, wedge formation of vertebrae and fusion of ribs in one case of congenital contractures of the fingers.

4. Complicating signs of degeneration and general developmental aberrations were found in 5 cases.

Acrocephaly in one case of syndactyly.

Malformation of genitals, high palate in 2 cases of contracted club hands.

Cleft palate in one case of aphalangism.

Three cases of this group showed deformities and contractures in all extremities.

5. Birth complications were found in 4 cases.

Instrumental delivery in 3 cases (1 syndactyly, 2 congenital club hands).

Twin birth and cord constriction in one case (contracted club hands and general contracture).

6. Primary developmental errors were assumed to be the causative agent in the majority of cases, in one case only amniotic constrictions could be held responsible; polyglandular (endocrine) dysfunction was suggested in 3 cases by malformation of the bones of the head and genital hypoplasia.

Ormerod, F. C. On the Treatment of Oriental Sore by X-Rays. (*Lancet*, October 30, 1920, p. 893.)

During 1918-19 the author treated a large number of oriental sores by applying *x*-rays and observed satisfactory progress in most and cure in a large percentage of cases.

The advantages of the *x*-ray therapy may be enumerated as follows: 1. The rays act directly on the causative organism. 2. They are able to penetrate unbroken skin or masses of diseased tissue, thereby being efficient in ulcerated and non-ulcerated sores alike. 3. Cases can be treated as out-patients and can very often continue their occupation. 4. There is no risk of constitutional disturbance, the danger of dermatitis or necrosis being absent with the doses utilized. 5. The treatment is short, painless and easy to administer. 6. Doses in awkward positions, such as the inner canthus of the eye, lips and alae nasi can be very readily dealt with. 7. The scars left after healing are supple and of such color after about six months as to be barely noticeable.

In conclusion, the author suggests that *x*-ray therapy may be of value in the treatment of the allied forms of leishmaniasis—espundia and kala-azar—as *x*-rays have an undoubted effect on the Leishman-Donovan body.

Haret and Truchot. Radiotherapy of Sciatica. New Technique. (*La radiotherapie de la sciatique. Essai de technique nouvelle. Bulletins et Mémoires de la Société de Radiologie médicale de France*, October, 1920, No. 72, p. 122.)

These authors briefly review the work of previous radiotherapists and describe the following as the technique they have used with the best results in eighteen cases. In six cases of sciatic neuralgia (pain symptoms only, without atrophy or change of sensibility and with normal reflexes) they got six cures with two and three series of five sittings each. In twelve cases of sciatic neuritis (continuous pain, muscular atrophy, trophic trouble, troubles of sensibility, abolition or diminution of the tendo achilles reflex) they got seven cures with three and four series of five sittings each; three cases much improved, with the same amount of treatment, and two cases only slightly improved, frankly considered as failures.

The authors refer to the differences of opinion of the massive dose and divided dose enthusiasts. They recommend the use of the Coolidge tube, four milliamperes of current, with twenty-five centimeter (ten inch) spark-gap;

anticathode-skin distance twenty-two centimeters (9 inches). The treatment was administered over the foramina of the fourth and fifth lumbar vertebrae and the first, second, third and fourth sacral vertebrae of the affected side. In one class of patients, they gave doses of three H. units measured under three millimeters of aluminum filter at eight day intervals. A second group of patients received 1 H. unit measured under three millimeters of aluminum every other day with an interval of one week's rest after five or six sittings. To a third group during five consecutive days they administered a daily dose of 1 H. unit measured under four or five millimeters of aluminum filter; then five days of rest. A new series of five sittings was then given with a daily dose of 1 H. unit followed again by five days of rest and so on. The authors have finally settled on this last technique as giving them the greatest degree of success. The different cases varied in their response to treatment, but generally one sees a definite improvement by the end of the second or third sitting. In a few fortunate cases, they have obtained cure with two series of five sittings each; they have never exceeded four series on anybody.

James T. Case.

Duncan, Rex. Epithelioma of the Lip, with Observations and Results in the Treatment of Eighty Consecutive Cases with Radium. (*Urol. and Cutan. Rev.*, xxiv, No. 10, 586, October, 1920.)

From a study of eighty consecutive cases, the author reaches the following conclusions: Epithelioma of the lip may occur at any age, near or after the third decade and in the absence of any definite etiological factor. Any wart-like, ulcerated or indurated lesion of the lip which persists more than two months under ordinary treatment, must be considered suspicious of malignancy. In questionable cases a section for diagnosis followed by immediate treatment is advisable. In the majority of cases, the macroscopic appearance is typical and a diagnosis can be made by a competent observer. Epithelioma of the lip is always a serious condition and should receive prompt treatment.

Radium therapy yields a higher percentage of cures than any other method of treatment. There results less inconvenience, loss of function and disfigurement than from surgery or other treatment. Palpable lymphatic glands should be immediately treated with radium. If unimproved after four weeks, they should be resected and radium buried within the wound. A uniform application over the lesion, and in certain cases the burying of the proper dosage within the tumor, are essential. This is obtainable only by the use of radium emanation.

Taft, A. Robert. The Comparative Value of Radium and X-Rays in the Treatment of Keloid, Nevi, Angioma, Leukoplakia and Other Lesions of the Skin and Mucous Membrane. (*Urol. & Cutan. Rev.*, Vol. xxiv, No. 10, p. 590, October, 1920.)

The author's results with keloid have convinced him that while the *x*-ray is a splendid remedy and the only one until the introduction of radium, yet the radium is even better.

In leukoplakia the hardest rays possible are advocated by everyone, and this in conjunction with the ease of application makes radium the ideal remedy.

In acne vulgaris the large area to be covered makes *x*-ray the choice, but in acne rosacea the author believes that radium is more efficient.

In lupus vulgaris, lupus erythematosus, ring worm, sycosis, etc., he has used the *x*-rays with such satisfactory results that he has hesitated to make a change.

It has been noted that in some skin diseases covering large areas, psoriasis for example, limited treatment with *x*-ray and clearing up a few lesions will result in a marked improvement of all other lesions. This is said to be due to some general effect. The author has treated in this manner lichen planus, various types of eczema, etc., and has seen many of these clear up generally as a result of a few local treatments. He believes the results to be due to absorption of killed diseased cells with formation of vaccines. It is so much easier to produce a local reaction in definite small areas that radium is better for this purpose than *x*-rays. Three cases of chronic genital sores were treated successfully within the last year by radium.

Angiomata, especially of the lips, responds well to radium, which is certainly the remedy

of choice although in larger growths fulguration followed by radiation is quicker and easier.

Nevi are better treated by radium than by any other method. Although warts respond well to radium, a less tedious and less expensive treatment is to be advocated in all but selected cases.

WILKINS, W. A. The Diagnostic Value of the *X*-Ray Examination in Pulmonary Tuberculosis (*Canadian Med. Assn J.*, Vol. x, No. 11, p. 99, November, 1920.)

Since the earliest days of roentgenology the aid of the *x*-ray examination has been invoked for diagnostic assistance in cases of suspected pulmonary tuberculosis and to-day its employment is a very important part of the routine examination of the chest. Nevertheless, there is considerable confusion concerning the interpretation of the shadows seen on the plate. The *x*-ray appearances of pulmonary tuberculosis vary with the stage of the disease. The shadow cast by the pathological tissues may be of any degree of density, including the faint filmy shadow of the very early case, the mottling of the more advanced disease and the dense shadow of the healed lesion. At times, the first indications of disease will be detected by the physical examination; at other times the *x*-ray alone will show the early changes and the *x*-ray affords the most accurate information that can be obtained apart from the autopsy, at least for the extent of the disease. Usually when physical signs are present, the *x*-ray will demonstrate the area of involvement to be more extensive than was indicated by the physical examination. No method or combination of methods at present employed will detect invariably the earliest signs of disease in every case nor decide positively at all times the activity of a lesion. The *x*-ray will demonstrate the site and the extent of the tissue changes, and although usually it is possible to infer from the *x*-ray plate alone whether the lesion is active or not, this decision should be left to the clinician to make. To discover on the *x*-ray plate indications of pathological changes in the tissues, usually requires the support of clinical evidence of disease, before concluding that the changes can be due only to tuberculosis. Otherwise the discovery may consist of nothing more than the recognition of a condition which has long since ceased to be a matter of medical interest. The clinical support need not be confined to the presence of physical signs within the chest, but may be manifested by the presence of general symptoms of ill health. Definite indications of pathological changes in the lungs so often are seen on the *x*-ray plate, not only in individuals who apparently are in perfect health, but also in those who give no history of having suffered from a serious illness at any time, that one is forced to the conclusion that tuberculosis of the lungs is frequently a mild disease, often running its course from onset to recovery unrecognized.

DAVIS, J. S. The Radical Treatment of *X*-Ray Burns. (*Ann. Surg.*, Vol. lxxii, No. 2, p. 224, August, 1920.)

X-Ray burns are usually caused by the use of *x*-rays in the treatment of skin lesions, such as psoriasis, eczema, superficial epithelioma; by frequent exposures extending over a long period of time in the treatment of inoperable or incompletely removed carcinoma; by the reckless use of the apparatus in the hands of unskilled operators and by long fluoroscopic exposures.

The author has had under his care burns situated in almost every region of the body. Some of them have been of the first degree, where the skin is reddened; a few of the second degree, where blisters formed; the vast majority have been of the third degree, where the full thickness of the skin and often the underlying tissues were involved.

Recent *x*-ray burns of all degrees should be treated as ordinary burns but unless there is a fairly prompt response to such treatment it is a mistake to continue it.

Palliative measures should be used in burns of the first degree. Paraffin films are often comforting; painting with collodion, or the application of sterolin (Formula: Balsam of Peru, 4 c.c.; castor oil and Venetian turpentine, of each, 2 c.c.; alcohol, 95 per cent, 100 c.c.), or some bland ointment, are useful.

In burns of the second degree, it is often difficult to tell at first the depth of such a burn, as one which seems to be merely blistered will turn out to be much deeper in places after the blisters have been removed. Wet dressings

have been found more comfortable in these cases than paraffin or ointments.

In burns of the third degree which do not heal promptly and permanently by the usual methods more radical methods must be adopted. The ulcer and surrounding area of induration should be excised with a wide margin out to and down to healthy tissue. After excision the defect should be grafted immediately if the base of the wound is of normal tissue, but if doubtful tissue is left, grafting should be deferred until granulations form. The type of graft used should depend upon the situation. The author uses "small deep grafts" in the majority of instances, but has used with satisfaction Ollier-Thiersch, or whole-thickness grafts in selected positions.

Pedunculated flaps from neighboring tissues, or from a distant part, have been of great use in situations where a pad of fat, in addition to whole-thickness, was necessary.

The best method of relieving the pain, aside from the excision of the affected area, is to divide the nerves supplying the area.

X-Ray or radium used in the treatment of *x*-ray burns has not been followed by any benefit. Patches of keratosis on the *x*-ray operator's hand, following frequent exposures without protection, may be successfully treated by freezing with carbon dioxide ice. Should the patches ulcerate, complete excision with immediate or subsequent grafting is the method of choice.

In instances in which tendons have been destroyed it is advisable to fill the defect with a pedunculated flap of skin and fat, and later to restore the tendon by the method best suited to the particular case.

Where large areas are involved we seldom excise sufficient tissue and infection sometimes occurs in the margins of these wounds. There may be sloughing of the entire margin of the wound, although the excision has been apparently complete. For this reason it is wise to defer grafting, or the transference of a flap.

In fulminating infections occurring in areas of the skin which have been burned by *x*-rays, prompt excision with a generous margin is indicated. Amputation of the part may be necessary to control the rapid spread of the infection.

The author's after-results of excision with grafting, or flap-shifting, have been most gratifying. Function has been restored in many instances and patients who have been incapacitated for years have been returned to their former activities.

Denis, W., and Martin, Charles L. A Study of the Relative Toxic Effects Produced by Regional Radiation. (*Am. J. M. Assn.*, Vol. clx, No. 4, p. 555, October, 1920.)

Constant extension of the field of roentgen ray therapy has brought into increasing prominence the condition of "treatment sickness," the constitutional reaction which frequently follows the use of massive doses of the hard roentgen rays. The underlying cause of this reaction is unknown. It has been ascribed to various and diverse factors. A factor which has been considered but little is one involving the question of the relative severity of symptoms following radiation of different parts of the body. The authors have collected the results of experiments with rabbits undertaken to determine whether by the radiation of certain portions of the body roentgen ray intoxication is more easily produced and in more severe form than by radiation of certain other portions.

It was found that a definite dose of roentgen rays administered to the body of a rabbit produces a severe systemic reaction and death only when some portion of the intestinal tract lies within the irradiated area. Furthermore, it is possible to produce a definite acidosis (lowering of the alkaline reserve) in rabbits by administering a heavy dose of roentgen rays over the abdomen. Such animals give no evidence of suffering from a "roentgen ray nephritis."

The results suggest the hypothesis that acidosis may be a factor in "treatment sickness" following abdominal irradiation.

Gunning, R. E. Lee. *X*-Ray Manifestations of Diseases of the Chest. (*Illinois M. J.*, Vol. xxxviii, No. 3, p. 196, September, 1920.)

The early diagnosis of pulmonary tuberculosis presents one of the most difficult clinical problems. The *x*-ray is merely an added form of examination but more exact. This form of examination should never be neglected any more than the stethoscope. It must be remembered, however, that a negative *x*-ray examination does not mean a normal lung. Positive evidence alone is of absolute value.

In all forms of chronic or sub-acute pulmonary tuberculosis with the clinical diagnosis evident, radiology is used simply to (1) confirm diagnosis; (2) differentiate pseudo-tuberculosis; (3) study development; (4) disclose complications; (5) furnish therapeutic indications.

The radioscopic appearance in these cases shows the widest variations as does the pathology. All manifestations from questionable shadows to absolute opacity or involvement of entire hemi-thorax or both pulmonary fields are seen. The most unexpected forms and localizations may be established. The stethoscopic signs may indicate severe involvement and the x-ray negate this and vice versa.

Abnormal shadows are seen most often to affect the apices and hilus in general. The shadows are scattered, varying in density and separated from one another by clearer spaces. Tuberculosis develops through foci. In confirmed tuberculosis, abnormal shadows are found on both sides but usually predominating on the side first affected. In advanced cases the shadows reach the lower lobes and the apices become spotted with clear zones due to cavitation.

Soiland, A. Cancer of the Lip. (*Urol. & Cutan. Rev.*, xxiv, No. 10, 599, October, 1920.)

Every lip case should first of all be given x-ray treatment to the entire neck and soft tissues of the lip and jaws, and this should be done most thoroughly. This procedure is now followed in the writer's service, whether or not glands are palpable. The lip lesion itself is then attacked, the method used depending upon the location and extent of the growth. When the lesion is rather superficial and involves not more than one-third of lip along both marginal borders, radium alone is sufficient. If it is a little more extensive and reflected downward over the skin surface, combined radium and x-ray give excellent results. If the lesion is more extensive and of cauliflower appearance, electrical desiccation by means of the Oudin bipolar method has given splendid results. After the slough has passed, careful radiation should follow.

Straight surgery of the lip is indicated only where extensive resection is contemplated, and should in all cases be supplemented by radiation.

Weinberg, Joseph A. The Influence of the Exposure of the Roentgen Ray on the Progress of Tuberculosis. (*Arch. Int. Med.*, Vol. 25, p. 565, May, 1920.)

It is generally agreed that the best method for diagnosing tuberculosis of the genito-urinary tract is by the inoculation of the urine of suspected cases into the peritoneal cavity of a guinea-pig. However, this test loses much of its practical value because of the time which must elapse before lesions are apparent in the animal after inoculation. This work was undertaken with two purposes in view: First, to shorten the time of development of tuberculosis; Second, to determine the rôle of lymphocytes as a factor in the protection of guinea-pigs against tuberculous infection.

The author was unable to hasten the progress of the tuberculosis appreciably by exposure of the guinea-pig to massive doses of the roentgen ray.

The leukocytes of the blood stream are markedly reduced in number by exposure to the roentgen ray. The reduction is proportionate to the length of exposure with a given current and voltage. The lymphocytes are most markedly affected.

The cells of the tubercle are probably derived both from the local tissue and the blood. The presence of the usual number of epithelioid and large mononuclear cells in the tuberculous lesions of roentgenized guinea-pigs, where there is a marked diminution of lymphocytes, indicates that these cells are not of lymphocytic origin. The presence of an excess of lymphocytes in and around the blood vessels near the tubercles in non-roentgenized animals indicates that cells are carried to the lesions by the blood stream.

Sittenfield, M. J. New Roentgenotherapy in Cancer (*J. Am. M. Assn.*, January 8, 1921.)

The writer reports methods of x-ray therapy used in three German clinics visited by him last summer. He states that they are using voltages of 200,000 to 220,000, tubes having been developed to permit this. With this high voltage, short waves are produced in sufficient quantity to permit using heavy filters and still have enough of an almost monochromatic radiation left to be of practical value, and its physical characteristics have been determined suffici-

ently well to know the amount of radiation in tissues at various depths. He stated that in passing through 10 cm. of soft tissue, only 70 per cent of the total radiation reaching the skin has been absorbed, thus permitting 30 per cent plus scattering to be effective in tissue of that depth. So he estimates that 40 per cent of an erythema dose can be administered to a uterus of the average patient without injury to the skin, and that by using four ports of entry, namely, front, back and two lateral, approximately a full destructive dose can be so given.

Summarizing, he says that the lethal dose for carcinomatous tissue is 90 per cent of the skin erythema dose, that for sarcoma 70 per cent, for ovary 25 per cent. Fibromyomata respond to one treatment, resulting in complete castration.

Carcinomata of the breast is not so situated as to permit of receiving approximately equal amounts of ray in front and behind. Here, though, the tumor is rarely more than 5 cm. from the skin surface; so by increasing the skin-target distance to 70 to 90 cm., 85 per cent to 90 per cent of an erythema dose can be administered to the tumor without injury to the skin, as the effect is in inverse ratio to the square of the focal distance. The time required is 320 to 535 minutes.

The technique as reported for uterine cancer in Bumm's Clinic in Berlin is to ray four areas, one in front, one from behind, and one from each side, using a voltage of 190,000 to 200,000. The skin-target distance is 30 cm., and with a filter of 0.8 mm. of copper for ninety minutes over each area. Blood transfusion follows this treatment.

At Seitz and Wintz's Clinic in Erlangen, six or seven fields are exposed, using 23 cm. distance, 16 inch parallel spark gap, 0.5 mm. of copper or zinc filter for thirty-five minutes each area. This treatment is given in two "sittings" at six weeks' interval.

At the Opitz Clinic of Freiburg, the focal distance is 50 cm. Four ports of entry are used and each rayed for 120 minutes. Astonishingly good results are obtained.

Eugene V. Powell.

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THE DIAGNOSIS OF PRIMARY TUMORS OF THE LUNG*

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A CONSIDERATION of primary tumors of the lungs must deal largely with malignant tumors, since those of benign type are exceedingly rare.

The most comprehensive and accurate description of primary malignancies in the lungs is the monograph of Adler, published in 1912. Adler states that the first accurate knowledge of lung tumors dates from modern times, after Laennec had established the clinical investigation of the chest on a sound basis by application of ausculation and percussion. This he calls the period of the study of lung tumors by clinical methods supported by gross pathology. His latest period, coming down to the time of his monograph, is that in which histology is added to clinical and gross pathological research. Since the publication of Adler's treatise the perfection of the roentgen method of examination of the chest has brought us to another period of much greater accuracy in diagnosis of intrathoracic neoplasms. Indeed, Adler wrote as follows in 1912: "It was not very long ago that A. Frankel wrote that *x*-rays were of little service in the diagnosis of lung tumors. Since then the *x*-rays have become a most remarkable and efficient aid to diagnosis in general, and there exists the well-founded hope of their increasing efficiency as further improvements in apparatus and advances in technique are made. . . . . The hope may reasonably be entertained that with the systematic and proper application of the *x*-rays to the exploration of the chest, the diagnosis of lung tumor may be assured when no other means will give equally certain results."

In 1917 McMahon and Carman, in a communication on "The Roentgenological Diagnosis of Primary Carcinoma of the Lung," described in detail the roentgen appearance of these tumors and gave the essential points in differentiating them from other intrathoracic conditions.

It is the purpose of this paper to state as concisely as possible the diagnostic points by which we are now able to recognize the presence of primary tumors in the lungs and to emphasize certain conditions that have come under the writer's observation from which such tumors must be differentiated.

It is undoubtedly true, as several writers have stated, that there is a certain roentgen picture that is practically pathognomonic of primary carcinoma of the lungs, but there are certain other conditions so closely resembling it that constant watchfulness is necessary to avoid mistakes. It is essential in every case to interpret the roentgenogram

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in the light of the symptoms, the physical findings, and especially the mode of onset and course of the disease. Unfortunately, like malignant disease in other parts of the body, tumors of the lung may be almost or quite symptomless, but in any case of suspected intrathoracic disease the possibility of lung tumor should always be considered.

The symptoms and physical signs depend not only upon the size of the tumor but more particularly upon its location.

Fig. 1. Primary Carcinoma of the Lung.

Fig. 2. Benign Tumor—Probably Intrathoracic Goiter.

There are usually no early symptoms that are characteristic, but there may be symptoms to arouse suspicion and lead to thorough investigation. Among the earliest of these may be a slight discomfort—at times amounting to pain—in an area corresponding to the hila of the lungs. There is often, also, a slight, gradually increasing dyspnea. Accompanying the discomfort and dyspnea there may be a dry, unproductive cough.

If these symptoms lead to careful physical examination of the chest, a small area of dullness may be discovered, especially a widening of the area of dullness about the root of the lung. There may also be diminished breath sounds, but no râles. If roentgen examination is made at this time, definite signs of pathology will be seen, depending upon the type of disease. If it is of the infiltrative type, having its origin in one of the large bronchi near the hilus, a roughly circular shadow will be seen extending outward from the hilus. The outer edge of this shadow is not sharply circumscribed but shades off into the surrounding lung shadow and has projecting from it processes that radiate out into the lung. Beyond this shadow which represents the pathological process itself is a more or less extensive area, somewhat less dense than the tumor shadow, and quite homogeneous in character. This is caused by congestion in the surrounding lung and probably also by a partial atelectasis due to some degree of stenosis of the bronchi. If in addition to the above picture there are a few nodules with the same indistinct edges surrounding the central shadow or in relation with the bronchial trunks farther toward the periphery, the picture is quite characteristic of malignant disease of the lung.

The infiltrative type of tumor may also arise from subdivisions of the bronchi or

from bronchioles far out in the lung structure. They show the same indistinct edges and projections as those arising at the hila.

In the miliary type of the disease there is diffuse nodulation throughout the lungs, but each nodule or mass of nodules has this same hazy appearance at its periphery, and there is present the surrounding zone due to congestion.

If the appearance described above is present, it may then be stated with a good degree of certainty that the lesion is carcinoma. There are, however, numerous cases of lung carcinoma in which the roentgen appearance is not entirely typical, and there are also conditions which are not carcinoma in which the roentgen appearance closely simulates the latter. It is in such cases that we must rely upon the future course of the disease and corroborative clinical findings in order to establish a diagnosis. The sputum may furnish conclusive or corroborative evidence. In rare cases tumor elements may be found or the fairly characteristic raspberry-jelly or prune-juice sputum may be present. The sputum is often bloody as in other lung diseases. The gradual increase in dyspnea due to growth of the tumor into the bronchi or trachea is a valuable sign. Barker mentions two cases in which he was led to a correct diagnosis by the presence of enlarged lymph-nodes in the neck. The microscopic examination of such a node removed from the neck or axilla may show the character of the process in the lung. The nature of the disease has occasionally been determined by the presence of portions of tumor in a pleural effusion. A hemorrhagic effusion is strongly suggestive of malignant disease.

It is stated that the diagnosis is sometimes established by bronchoscopic examination. Fever is of variable occurrence and is probably due to the presence of inflammatory reaction about the tumor. It may vary from 99° to 102.5°.

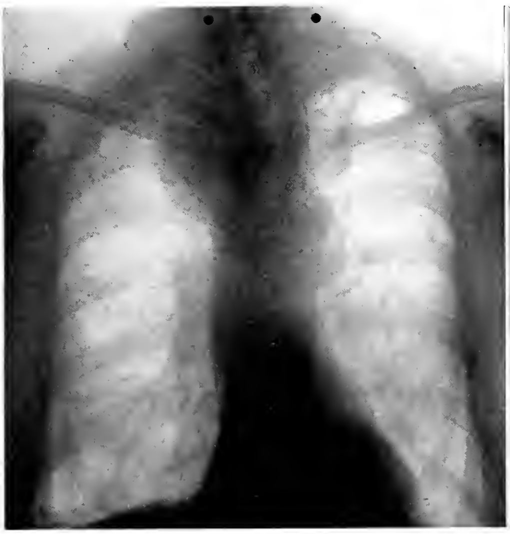

Fig. 3. Benign Tumor, Probably Dermoid Cyst.

Fig. 4. Echinococcus Cyst of Lung.

Two cases of lung carcinoma which have come under the writer's observation depend for diagnosis upon the manner of onset, the progressive course of the disease, and the roentgen findings, which are quite typical. Both of these cases were men between fifty-five and sixty years of age. The clinical and roentgen aspects of these two cases are strikingly alike. In both cases the first sign of the disease was a sudden attack of fever and cough. The fever disappeared in a few days, but the dry cough persisted. In one of the cases there were several attacks of fever varying from 99° to 102.5°. One came for roentgen examination eight months, and the

other six months after the initial attack of fever. In one of them the clinician had discovered a definite area of dullness extending outward from the left hilus—in the other no suspicious physical signs had been found in the chest. In both cases the most prominent symptom was the persistent, irritating cough, but both complained of a feeling of tightness and discomfort in the region of the root of the left lung. Both patients had a slightly cachetic appearance and both had lost a few pounds in weight. Both cases have been given two series of roentgen treatment through many portals of entry with no apparent improvement. One has been under observation about four months, and the other about six months, and in both there has been a gradual increase in the cachetic appearance and a gradual loss of weight. Figure 1 shows the roentgen appearance in one of these two cases.

Benign tumors of the lung occur infrequently but often enough to make it necessary to mention them briefly. It is often possible to make a diagnosis of benign lung tumor when the exact nature of the tumor cannot be stated. For example, Figures 2 and 3 undoubtedly represent benign tumors since they were both observed over a period of more than three years without change in size or contour. Figure 2 is probably an intrathoracic goiter, while Figure 3 is very likely a dermoid cyst.

Echinococcus cyst sometimes occurs in the lung, usually in the lower right lobe. Figure 4 represents a cyst which is believed to be echinococcus, but conclusive evidence such as hooklets in the sputum or positive complement fixation test, was absent. The round or oval, sharply circumscribed contour of benign tumors and their smooth margin makes their roentgen appearance rather typical.

Fig. 5. Mediastinal Tumor.

Fig. 6. Mediastinal Tumor.

The following intrathoracic conditions may simulate lung tumors more or less closely and must be considered in the differential diagnosis.

Mediastinal tumor can usually be distinguished by the roentgenologic appearance. Oblique examination will show a distinct mass in the mediastinum, and examination in the antero-posterior direction will show the shadow directly continuous with

that of the mediastinal structures. (Figs. 5 and 6.)

In mediastinitis there is a general widening of the mediastinal shadow, and those

Fig. 7. Intrathoracic Goiter.

signs and symptoms that accompany an inflammatory process.

Intrathoracic goiter and *cystic tumors* of the mediastinum give a rather characteristic roentgen picture. (Fig. 7.)

Gumma of the lung is a condition having much the same roentgen appearance as malignant tumors (Figs. 8 and 9). The diagnosis depends upon the Wassermann test and the disappearance of the mass under anti-syphilitic treatment.

Caseous pneumonia may readily be mistaken for malignancy. The early symptoms may be quite indefinite just as they are in malignant disease, and the roentgen picture may not be distinctive. The irregular temperature, gradually becoming higher as the disease progresses, the presence of râles, the finding of tubercle bacilli in the sputum, and the character of the sputum may serve to differentiate from lung tumors.

There are certain inflammatory processes occurring at or near the hila of the lungs that give much the same roentgen appearance as malignant disease. Such conditions are often seen following influenza, but they may arise quite independently of other disease. We have observed several such cases apparently caused by the streptococcus hemolyticus. These conditions are sometimes a bronchial adenopathy but some of them are undoubtedly localized pneumonic processes. Most of them undergo resolution very slowly and it is at this time, when the patient is afebrile, that a mistake may be made in

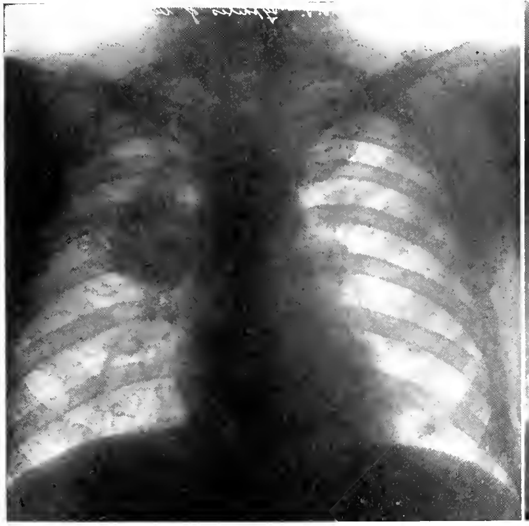

Fig. 8. Gumma of Lung.

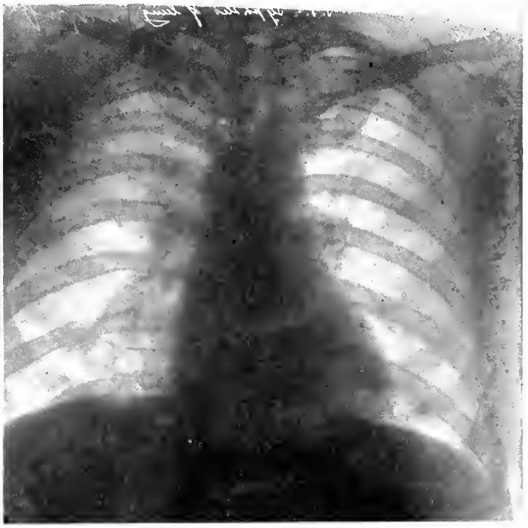

Fig. 9. Gumma of Lung. Same Case as Fig. 8 after Treatment.

diagnosing the condition as malignancy of the lung.

There are other conditions, such as bronchiectasis, chronic pulmonary abscess, encysted empyema, pulmonary infarct, and metastatic malignancy, that may be confused with primary malignant tumor of the lung. Careful attention to the history and the roentgenologic findings will in most cases serve to separate them.

It may be stated in conclusion that an accurate diagnosis of lung tumor, with a definite opinion as to its malignant or benign character, can be made in many cases by consideration of the mode of onset, the preliminary symptoms, and the roentgen findings. When, however, the roentgen appearance is not characteristic, the diagnosis must be established by the further course of the disease, and the presence of such signs as enlarged lymph nodes in the neck or axilla, and the character of the sputum and pleural effusions.

It must further be kept in mind that there are certain non-cancerous conditions occurring in the lung which may readily be confused with cancer, especially if only the roentgenologic evidence is relied upon. Among those especially likely to lead to error are gumma of the lung, mediastinitis, caseous pneumonia, and certain inflammatory processes about the hila.

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DISCUSSION

Dr. G. E. Pfahler.—This paper has been so beautifully presented I don't see that there is very much to add. I can only congratulate Dr. Christie on his presentation.

Dr. F. W. Manges.—I too think Dr. Christie's a most interesting and important paper. It has been but a comparatively short time that we have been considering primary carcinoma of the lung, except as a very rare entity, if an entity at all, and I think largely because of the roentgen signs which we found difficult to explain otherwise. In other words, it has been because we have not been able to differentiate our findings clearly that the diagnosis of primary carcinoma has become quite common in the last few years, so that I think this is a most important question now, especially to roentgenologists. Every year our problems of differentiating conditions in the chest are becoming more and more difficult, more and more complex. It must prove to all of us that we made many mistakes in the past, so that I think the paper of Dr. Christie, like that of Dr. Watkins and a number of others on the chest at this meeting, have been most valuable indeed.

I am not going to discuss the paper in the sense that I disagree in any way with Dr. Christie, because I don't. I would like to support practically everything he said.

Dr. George C. Johnston.—I have never seen a case of pleural effusion in primary malignancy. It may be that the cases are not

far enough advanced or that they die too soon, or I don't get to see any of them. It is my opinion you get your pleural effusion in secondary carcinoma.

Now, if we take up these cases of primary carcinoma, pretty soon we will have the internist thinking about it when he is examining a man, and you will find they are not at all rare, but are simply overlooked. I have seen a number of cases of primary carcinoma of the lung, and to my surprise, I found they were practically all coming from one man, and he was not the best posted internist I had to work for, either. He was one of the old school of men, and in curiosity I asked him why he was making so many diagnoses of carcinoma of the lung that we could support roentgenologically. He said it was probably because he was thinking about it when he examined the patient. Then I asked him what he based his diagnosis on in some of these cases, and he replied that if you are going to explain afebrile hemoptysis without any pneumonia, it is pretty hard to do.

Dr. A. C. Christie (closing). We often have pleural effusions in primary carcinoma. One of these cases of mine had a pleural effusion, and many reported have had pleural effusions which had to be withdrawn before an accurate picture could be obtained.

I would like to emphasize what Dr. Manges said that the disease is common. It is not such an uncommon disease as we once believed and we must think about it always. Adler reported 374 cases in 1912, and he accepted only those which had been proven by pathologic section. McMahon and Carman reported some 460 cases in 1918. There may have been quite a number since, so there must be a great many more cases than have been reported. Some think it is not very important whether we make an actual diagnosis or not, because the patient is doomed any way, but I think it is a matter of great importance to the patient. Aside from the question of scientific accuracy in diagnosis, it is of great moment to the patient whether he is going to be moved around from here to there as a tuberculosis patient for the rest of his life, with the final destruction of false hopes that he may get well, or whether it is definitely known from the beginning that he has a malignant disease.

THE CLINICAL IMPORTANCE OF THE DIFFERENT TYPES OF PULMONARY TUBERCULOSIS AS DETERMINED BY ROENTGEN EXAMINATION*

By R. G. ALLISON, M.D.

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In attempting to classify pulmonary tuberculosis into clinical and non-clinical types by means of the *x*-ray, I would like to assure you at the outset that I am fully aware of the difficulties that are to be met with, and am convinced that it cannot be done without a certain percentage of error. I am equally convinced that unless we do attempt this classification we have not done our full duty either by the patient or by the clinician who has referred him to us for an opinion. Entirely too much time has been spent by both roentgenologists and clinicians in advancing absurd claims as to the relative merits of the stethoscope and the *x*-ray in discovering the earliest tuberculous change in the lungs, and entirely too little time spent by either of them in investigating the clinical significance of the lesions when found.

In the past there has been too much hesitancy on the part of the roentgenologist to make, and on the part of the clinician to accept negative diagnoses of pulmonary tuberculosis in the face of toxic symptoms.

Giffin of the Mayo Clinic says: "From the comparison of the two methods we would conclude that pulmonary tuberculosis can be shown as early by the *x*-ray as we can be sure of its presence by other methods, and the negative evidence obtained has in our

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

experience been of greater value than the positive." Lawrason Brown of Saranac Lake says: "By stereoscopic plates a diagnosis can be made long before physical signs are definite." Rist of the Lannec Hospital of Paris states: "To argue that a pulmonary tuberculosis sufficient to give physical signs would not show definitely on the *x*-ray plate, shows an ignorance not only of the fundamental principles of roentgenology, but of physical diagnosis as well." Thus it would seem that in stereoscopic plates we have the one accurate method of definitely excluding pulmonary tuberculosis.

It is my belief that the greatest factor in making roentgenologists reluctant to make, and clinicians reluctant to accept negative diagnoses of pulmonary tuberculosis, has been the non-recognition or non-acceptance of the fact that there are no symptoms or set of symptoms pathognomic of pulmonary tuberculosis. Until clinicians and roentgenologists accept this fact, the one will be always loathe to make and the other loathe to accept a negative diagnosis in the face of toxic symptoms. Further in this relation I would include in the category of negative diagnosis of pulmonary tuberculosis not only normal lungs, but also lungs showing non-clinical types of tuberculosis.

In my opinion our reports to the referring physician should consist of an objective description of our findings, our impression of these in terms of pathology, and finally our opinion as to whether the lesion is or is not a clinical type of infection. If all our cases were referred by internists and tuberculosis specialists capable of translating objective descriptions of shadows into terms of pathology either obsolete or recent, this might not be necessary; but the majority of cases do not come from them. It has been my experience that by far the greater number of chest cases referred to the roentgenologists come from the general practitioner; and the majority of these are sent for the simple reason that they are presenting symptoms suggestive of an active tuberculosis, with absent or equivocal signs, and the information which the physician desires can be summed up in two questions: (1) Has this patient pulmonary tuberculosis? (2) If so, is it of a type which could account for his symptoms? It is my belief that the first question can be answered correctly in practically every instance. The second can be answered with such a high degree of accuracy, that it should never be neglected, especially as it is the question upon which the whole value of the roentgen method depends. So much has been written on the early diagnosis of pulmonary tuberculosis, and the fact that physical signs may be absent so emphasized, that as Rist aptly expresses it, confronted by a patient, our attitude is not "What ails the patient?" but "Can't we find some tuberculosis to account for his symptoms?" It is in this type of case—and these form at least half of the cases we see—where by making a definite negative diagnosis of a clinical type of tuberculosis, we can start the physician on a further search for the real cause of the patient's symptoms.

Otherwise, if we describe an obsolete tuberculosis as seen on the plates, without an expression as to its clinical significance, the physician will immediately attribute the symptoms to it and the patient be doomed to a sanitarium existence, with all the interference with his future life which that entails. Only a week ago I heard one of our noted sanitarium physicians say: "It is only since I have become convinced of the value of a negative *x*-ray diagnosis of tuberculosis that I found how many different conditions I had been treating as pulmonary tuberculosis."

We as roentgenologists would be far more accurate and valuable if we would confine ourselves to speaking in terms of clinical and non-clinical types of tuberculosis and base our opinions wholly upon the findings of the plates, rather than be biased by the patient's symptoms, and attribute activity to an obsolete infection. Naturally the patient has symptoms or he would not have consulted his physician, and his symptoms are suggestive of pulmonary tuberculosis or he would not have been sent to us. Our duty is to say

whether there is a pulmonary tuberculosis present which is capable of producing symptoms, and there our duty ends.

I hope I may be pardoned for having dwelt so long on these simple facts, but for five years I worked in clinical tuberculosis, and during part of that time I received dictated chest reports. During that time the reports were a conglomeration of "increased linear markings," "bronchial interweavings," "tobacco smoke cloudings," and "apical shadows," without any attempt generally to convert these findings into terms of pathology and anatomy and never any attempt to state their clinical significance. Usually I was more in doubt as to what the patient had after reading the reports than before. It is because I can see this from the standpoint of the clinician that I have dwelt so long on the necessity and value of an opinion from the roentgenologists as to the etiology and clinical significance of the objective findings.

From a roentgen standpoint all pulmonary tuberculosis can be grouped under three divisions: (1) The pulmonary miliary process which accompanies a generalized miliary tuberculosis and is hematogenous in origin. Its appearance is characteristic, readily recognized, and seldom confused with other conditions. Its clinical significance need not be touched upon. All pulmonary tuberculosis other than this form can be classified definitely as either (2) parenchymatous or (3) peribronchial, depending upon whether the involvement is in the lymphoid tissue surrounding the bronchus or in the air vesicles themselves. In case both types are present it should be classified as parenchymatous.

The roentgen differentiation of these two types is simple, definite and necessary. It is beyond the scope of this article to delve into the different theories on the mode of infection in pulmonary tuberculosis.

Gohn's classical work on the lungs of children would indicate that all peribronchial tuberculosis is secondary to a parenchymal focus, which may be active or healed, large or small. Regardless of its etiology peribronchial tuberculosis can be definitely differentiated from the parenchymal form by the x-ray. The roentgen appearance of parenchymatous tuberculosis from its slightest to its most advanced changes is perfectly familiar to all of us and a description need not be indulged in. The only condition which resembles it closely is an atypical bronchial pneumonia, and here at times we must resort to the time-honored custom of watchful waiting in order to decide with which condition we are dealing. With a history of recent influenza or pneumonia I should wait for a few weeks, for a second set of plates, before pronouncing a slight infiltration or consolidation tuberculous unless there were definite evidence of fibrosis or calcification present.

If the conglomerate tubercles which make up this type of infection are few in number and definitely calcified, and the linear markings extending toward the hilus from them show a cleancut shadow, I do not consider the lesion of clinical significance. Unless it does exhibit this appearance I report it as a clinical type of infection.

Peribronchial tuberculosis, to be considered of clinical importance, should be upper or middle lobe distribution, gross in amount, either unilateral or more marked on one side as compared with the other, and should exhibit a hazy outline and a definite nodular appearance. Unless involvement of the peribronchial tissue conforms to these qualifications it represents either a non-tuberculous infection or is merely the residue of an obsolete tuberculosis.

I have followed the plan just outlined in reporting all chest cases. I have first given the objective findings, then attempted to convert these into terms of pathology. Following this I have then given a positive or negative opinion as to the clinical significance of the lesion.

I have probably missed several cases of active tuberculosis, and I am quite sure that in many of the cases I described as having a clinical type of tuberculosis, the tuberculosis was quiescent and the cases were suffering from other conditions which were producing their symptoms. But on the other hand I am

quite sure that in most instances where a negative diagnosis was given, the physician by a further search was able to find some other disease as the cause of the patient's symptoms.

CONCLUSIONS

1. Pulmonary tuberculosis can be divided into clinical and non-clinical types with a high degree of accuracy by stereoscopic plates.

2. Unless we make this division into the two types we are putting our method on the level of tuberculin, which will not differentiate between infection with the tubercle bacillus and the disease tuberculosis.

3. Negative stereoscopic plates can with an occasional rare exception exclude a clinical type of tuberculosis.

4. Parenchymatous tuberculosis is a clinical type unless slight in amount and definitely calcified, and peribronchial tuberculosis is of clinical significance only where it conforms to the following qualifications, upper or middle lobe distribution, unilateral or more marked on one side as compared with the opposite, gross in amount and presenting a hazy outline with definite modulations.

5. A negative diagnosis from the roentgenologist is of more value than a positive, in that in the face of suggestive symptoms, a positive diagnosis can often be made by other methods, but the *x*-ray alone offers the only accurate method of excluding the disease.

THE VALUE OF LATERAL AND OBLIQUE STUDIES OF THE CHEST*

By WILLIAM A. EVANS, M.D.

DETROIT, MICHIGAN

IN reviewing the literature on tuberculosis in children, one wonders at the wide variance of opinion held by men prominent in chest work as to diagnosis and location of lesions. It is agreed that the diagnosis is difficult, and while one writer insists that physical signs are to be depended on first, if not almost entirely, another declares that the ordinary methods of examination are of little value, and that history alone will suffice to determine the diagnosis.

References to the pulmonary area involved are equally conflicting. Fishberg, in an article in the Medical Record in 1917, states that parenchymal lesions are invariably apical, as in adults. This is in direct contradiction to the usual view that parenchymal tuberculosis in children is invariably of the lower lobes. Most of the later workers agree that the roentgen method of examination of the chest is most valuable, some declaring that it is the only method by which a correct diagnosis can be made. Inasmuch as parenchymal tuberculosis is extremely rare in childhood, and peribronchial tuberculosis and a peribronchial lymph node tuberculosis are but secondary developments of a primary root infection, it is evident that the ordinary postero-anterior plates of the chest cannot have a proper diagnostic value for tuberculosis, since the visible changes in this condition to a large extent and for some time occur in the nodes which surround the trachea and the first portion of the bronchi, and these structures are obscured by the heart and large vessel shadows.

We have had the opportunity recently to check physical and radiographic findings, and it has been observed in the cases in which the infection had spread to the outer bronchial, bronchopulmonary and pulmonary nodes, the findings were in harmony, but when the physical findings—and in these cases the d'Espine sign was held diagnostic—were not in accord with the pathology demonstrated by the ordinary plates, lateral

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

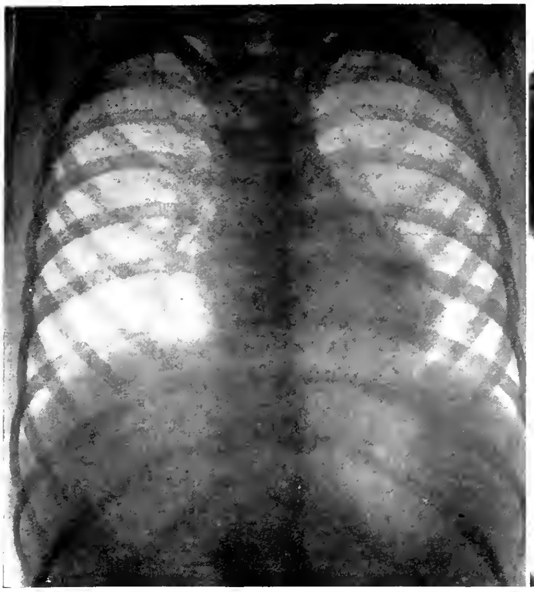

Fig. 1. Case I. An Ordinary Posterior-anterior Plate of a Child's Chest Showing the Accentuation of the Hilum Shadows and Increased Markings Upwards.

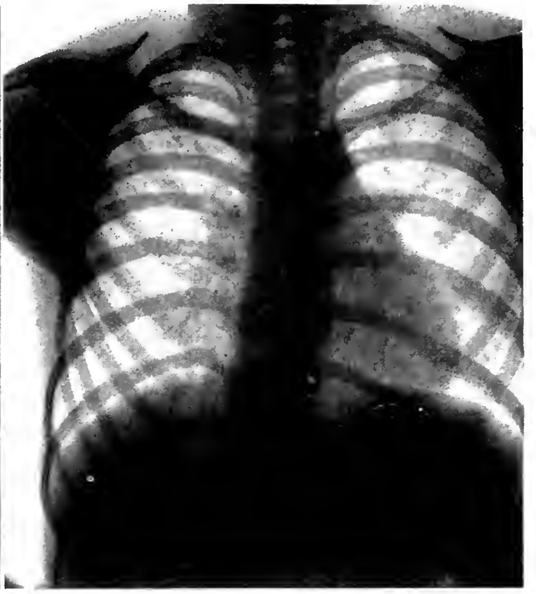

Fig. 3. Case II. Ordinary Postero-anterior Plate of the Chest of a Child. No Abnormality Noted.

Fig. 2. Case I. Lateral Plate of the Chest Showing the Calcified Glands and Marked Hypertrophy of the Lymphoid Tissues in the Space between the Heart and the Spine.

Fig. 4. Case II. Lateral Plate of the Chest Showing Extensive Deposit between the Heart and Spine.

plates revealed the enlargement of the tracheal and inner bronchial glands.

We are not to gather from these statements that the diagnosis of tracheobronchial tuberculosis can be made from the radiographic examination alone, for there is nothing characteristic about the enlargement of the glands resulting from infection with the Koch bacillus; but it is important to use a method which will demonstrate the basis for physical signs, and the lateral plate will do this frequently when the standard positions give negative findings.

At this time, I should like to refer to the results of experiments by Krause given in a paper entitled "Experimental Tracheobronchial Node Tuberculosis" published in the *American Review of Tuberculosis*, March, 1919. In these experiments an attenuated strain of Koch bacillus was injected in the groins of guinea pigs. Serial studies demonstrated an early and relatively extensive involvement of all of the lymph nodes in the vicinity of the point of infection. It was supposed for some time that the infection did not spread beyond the abdominal lymph nodes, but later studies showed in all cases involvement of the tracheo-bronchial nodes. Dr. Krause's conclusions from these experiments tend to disprove definitely the Ghon theory that all tuberculosis of the hilus glands is secondary to a pulmonary parenchymal lesion. Dr. Krause suggests that he could agree with Ghon's theory provided the word infection was used rather than lesion, because it is no doubt true that the lymph nodes are, in many cases, infected by inhalation, the organisms being absorbed by the terminal pulmonary lymph vessels.

The value of the lateral study of the chest in adults is particularly great in those cases which present deep-seated abscesses or interlobar collections of fluid. The position of parietal effusions can be easily determined by plates made in both anteroposterior and postero-anterior positions, the size of the shadow, of course, varying on the two sets of plates. The ordinary stereoscopic plates are of no value in these diffuse intrathoracic shadows, because the relation of the density to the anterior or posterior chest walls cannot be determined by this method of study. If the margins of the encapsulated fluid were always spherical or regular, the lateral method would have no special advantage; but frequently the outline of a retained fluid is triangular, so that by the lateral plates the points of approach for thoracentesis or thoracotomy can be advantageously chosen.

The possibility of a successful drainage of a lung abscess by collapse of the lung through artificial pneumothorax can also be determined in advance of the procedure, for in abscesses which are situated near the periphery of the lung, there are frequently adhesions between the pulmonary and parietal pleurae, which prevent lung collapse. This question is especially timely because there are many internists in the country who are electing to treat acute pulmonary conditions by artificial pneumothorax when the pathology present should demand surgical treatment.

The shadow of the right leaf of the diaphragm on the average chest plate is at the level of the eighth or ninth rib posteriorly, the exact level depending on whether the plates were obtained in deep inspiration or in expiration. The lines of reflection of the pleura inferiorly are anteriorly at the level of the eighth costochondral junction, mammary line, the tenth rib in the midaxillary line, and thence to the spinous process of the twelfth thoracic vertebra. The variation between the two sides is unimportant. Therefore any pathology occurring in the posterior phrenocostal space cannot be shown on the standard anteroposterior plates. It is true that plates made in deep inspiration reduce the depth of this hidden field, but at no time is the diaphragm entirely flat. Again, any inflammatory pathology involving the lower lobes causes a fixation and elevation of the diaphragm on the affected side, and the depth of the area under discussion is correspondingly increased.

The lower right lobe is a favorite locality for abscess, probably due to the predilection for foreign bodies to enter the right bronchus.

FIG. 5. CASE III. ORDINARY POSTERO-ANTERIOR PLATE OF AN ADULT'S CHEST SHOWING A HYDROPNEUMOTHORAX.

FIG. 7. CASE IV. POSTERO-ANTERIOR PLATE OF THE CHEST SHOWING A HYDROTHORAX.

FIG. 6. CASE III. LATERAL PLATE SHOWING THE COLLECTION OF FLUID IN THE POSTERIOR PART OF THE CHEST. NOTE FLUID LEVEL OVERLYING THE SHADOW OF THE SPINE.

FIG. 8. CASE IV. LATERAL PLATE OF THE CHEST SHOWING THE WIDE DISTRIBUTION OF FLUID FROM THE ANTERIOR TO POSTERIOR CHEST WALL.

Descriptions of three cases recently studied will serve to illustrate the practical value of the lateral and oblique studies of this area.

Case I. Mrs. S, age forty-five. Referred for chest examination with the history of an acute process in the lower right. The findings, at this time, were those of a small amount of fluid in the right lower pleural cavity, there being a loss of the phrenocostal angle. However, the development and severity of the symptoms were out of proportion to the findings, and following withdrawal of the pleural effusion, further studies were undertaken to determine the basis for the persistence of the symptoms. At this time, by the oblique method, we could demonstrate a rounded shadow just below the shadow of the right leaf of the diaphragm, and accordingly a report was made that a lung abscess was present, and that the pleural effusion formerly demonstrated was simply secondary to the deeper lesion. Several days following this examination, in a paroxysm of coughing, the patient brought up a peanut with a quantity of pus, and the case went on from this to complete recovery. At the time of both examinations, no history whatever was obtained that would suggest the presence of a foreign body.

Case II. Mr. C., age twenty-three. The chest plates showed pulmonary pathology involving the lower right lobe, complicated with a small amount of pleural effusion. The patient apparently recovered from this condition, although previous to his discharge from the hospital no radiographic record was obtained of the chest condition. After a lapse of three months, the patient was again referred for examination of the abdomen, with a tentative diagnosis of duodenal perforation or duodenal ulcer. Study of the chest at this time revealed a fixed and elevated right leaf of the diaphragm, with no free fluid in the pleural cavity. The abdominal findings were those of adhesions involving the first and second portions of the duodenum. We described the pathology in the lower lobe, but we did not appreciate its clinical significance, as later events proved.

At operation, adhesions were found in the upper right quadrant, but during the anesthesia, the patient had a severe paroxysm of coughing, and a considerable quantity of pus was expectorated.

We felt that we were at fault in this case, because we did not attach more importance to the pulmonary findings. Due consideration of the oblique findings would have resulted in a very different method of treatment.

Case III. Mr. C., age seventy, with a history of pneumonia which did not clear up within the usual period. Radiographic study of the chest in the standard positions demonstrated a small amount of fluid in the lower right. Again, the symptoms were out of proportion to the findings, and the oblique method of study revealed lower lobe pathology, in addition to the small amount of fluid.

At the time of operation, when the pleural cavity was opened, there was escape of a thin, sanguineous fluid, and not until the lung itself was entered was pus obtained.

A third area in the chest obscured by anatomic structures is the space between the heart and the posterior chest wall. Internists have frequently questioned the interpretation of chest findings in a given case, inquiring as to the possibility of a pulmonary lesion being obscured by the heart shadow. Our experience with Case IV of this series will serve to emphasize the need of having in mind the possibility of collections of fluid which can be obscured by the heart, the heart in the meantime showing no displacement.

Case IV. Mr. H., age twenty-six, post-influenzal pathology. The anteroposterior plate showed slight impairment of density over the lower left lung field, with a visible left leaf of the diaphragm and no displacement of the mediastinal shadows. In spite of

our negative report for the presence of any quantity of fluid in the left pleural cavity, a thoracotomy was performed and a pint or more of pus was evacuated. In this case, also, we believe that thorough lateral and oblique studies would have revealed this collection of fluid.

Fig. 9. Case v. Postero-anterior Plate of an Adult's Chest Showing Elevation and Distortion of the Right Leaf of the Diaphragm.

CONCLUSIONS

I am well aware that the above procedure in the examination of the chest is carried on by many workers. My object in presenting it at this time is to emphasize the necessity for a more frequent variation from the standard positions.

The mere reporting of a small amount of fluid in the lower pleural cavity is of no practical value in many chest conditions, for the presence of the fluid is merely incidental to the basic pathology, which is pulmonary.

As regards juvenile tuberculosis, the wide divergence of opinion regarding the mode of infection and the distribution of lesions indicates the necessity for immediate and wide promulgation of the views held by roentgenologists who are familiar with the type and location of visible lesions of tuberculosis.

DISCUSSION

Dr. Kennon Dunham. I wish to thank Dr. Evans for bringing to our attention again the necessity for as complete an examination of the chest by the *x*-ray as is possible. I am sure that he does not mean that we should give up the ordinary stereoscopic postero-anterior exposures from which we gain so much, but he does mean, or at least I think he means, that that is not always sufficient, and it is of utmost importance that every aid should be given to determining these lung tumors. For years *x*-ray men have been working in the lung field, and have had almost no encouragement from the medical profession. The war changed that. They are coming to you and to me to help them solve their chest problems. Just as in Dr. Stewart's work, the bronchoscopist is absolutely dependent on the *x*-ray examination. Now, when we have made an examination, don't let us stop because we are in a hurry. Don't let us get

Fig. 10. Case v. Lateral Plate of the Chest Shows Adhesions Involving the Diaphragm well Interior. the Posterior Surface is Clear.

This plate shows graphically the extent of the pulmonary area which is obscured by the ordinary postero-anterior plate.

into a hurry which may cause us to lose an important phase of an examination.

Before I sit down, I simply wish to impress on you that wherever it is possible, please impress upon your clinician that the aid of the x-ray is not only necessary in cases they think are important; the great importance of the x-ray examination of the chest is where they do not have sufficient physical signs to explain the case. The greatest benefit we have received from the x-ray examination has been where it has been done routinely. Every case coming to a hospital should be examined, and that is where you get your beautiful results and most illuminating work. It helps the clinician and then, for the first time in the clinician's life, he wakens up to the fact that his physical examination has its limitations just as the x-ray examination has its limitations.

But this method of Dr. Evans' impresses on us the value of the lateral and oblique exposures of the root of the lung, and possesses inestimable value. The stereoscopic plate becomes helpless in front of an absolute density. We cannot stereoscope heavy densities—we do not stereoscope the heart, but they must be studied, and to do this we must find a way. Dr. Evans has shown the way.

A SIMPLE AND PRACTICAL METHOD FOR THE RAPID HARDENING OF GAS TUBES

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At the present time there are three recognized methods of hardening gas tubes which have become too soft for use:

1. Tubes may be hardened by setting them aside and allowing them to rest for an indefinite period.

2. Tubes may be hardened by passing a weak current through them for several minutes, either through the true or through the accessory anode. The current must pass through the tube until the tube is hot.

3. Tubes may be hardened by being repumped at the factory. The first two methods are time-consuming and unreliable, failing completely in the case of very soft tubes. The third method is time-consuming, inconvenient and expensive.

The possibility of hardening x-ray tubes rapidly and conveniently by cooling the softening device with an ethyl-chloride spray or other means suggested itself on theoretical grounds. The efficacy of the method has been demonstrated by the successful hardening of twenty-five different gas tubes. Up to the time of publication fifty tubes have been succesfully hardened. After a short discussion of theoretical considerations we shall give in detail our practical methods and results.

THEORETICAL CONSIDERATIONS

The fact that gas tubes become harder on standing suggests the occurrenee of condensation and absorption or adsorption of gas by the tube wall, anode or softening device, and particularly the condensation and absorption of water vapor. The experimental work which resulted in the production of high-vacuum Coolidge tubes taught us that the ordinary low-vacuum tube contains a considerable amount of water vapor. The construction of the ordinary softening device, which consists of some hygroscopic material, such as asbestos packing so placed that it can be heated by the electric current, leads us to believe that the softening of the tube consists generally in the liberation of water vapor and that the hardening which takes place on standing is mainly due to the resorption of the water vapor previously lib-

erated. While the condition of the tube wall and that of the anode and cathode are undoubtedly factors in the state of hardness of the tube, it is probable that most of the resorption takes place in the softening device which, because of its relatively large surface and hygroscopic character, is best adapted for this function.

The avidity with which finely divided substances, such as animal charcoal, absorb gases when cooled to a very low temperature, as by liquid air, suggests the possibility of hastening the resorption of gas or water vapor in a gas tube by cooling the softening device. The rapid fall in vapor tension of water with fall of temperature suggests that the use of even a mild cooling device, such as the ethyl-chloride spray, will be fairly efficacious in causing condensation or increased concentration of water vapor in the cool part of the tube and hence increased resorption and consequently increased exhaustion or hardness. These theoretical considerations are borne out by the practical results which follow.

PRACTICAL METHOD AND RESULTS

The actual method of hardening the tube is as follows:

1. Current is passed through the tube until it becomes fairly hot.

2. The softening device of the x-ray tube is sprayed slowly with ethyl-chloride. From thirty to fifty grams is generally sufficient, and during the spraying a coating of snow and ice should collect on the glass bulb of the softening device. It is advisable to protect the bulb of the tube with a towel, exposing only the chamber containing the softening device. A thin layer of absorbent cotton held down by two or three rubber bands placed around the tube wall containing the softening device facilitates the spraying of ethyl chloride. By this method none of the ethyl chloride is wasted or lost and the formation of snow and ice is hastened.

3. Allow the tube to stand five minutes. Dry the tube thoroughly. An electric fan aids in cooling the softening device during the spraying, and also later in drying the chamber containing the softening device.

4. Reheat the tube by passing the current through the anticathode or accessory anode. After this procedure it is generally found that the tube is harder than before and becomes progressively harder for about twenty-four to forty-eight hours. Different tubes vary in the ease with which they are hardened; some require only one treatment and others several repetitions of the treatment. Once the spark-gap has begun to increase it is easy to increase the hardness of the tube to any desired degree by repetition of the above treatment.

On the following page will be found a table containing a list of twenty-five tubes rehardened by this method.

SUMMARY

As a result of our experiments with twenty-five gas tubes of several different types, we wish to emphasize several points which will be useful to any one employing this procedure. It makes very little difference whether the asbestos packing in the softening device is in direct contact with the outer glass wall or is contained in a separate tube. In general older and more highly seasoned tubes require more preliminary heating and respond to treatment more slowly than do newer tubes. The reason for this is that the tube must be heated sufficiently to drive particles of gas from the metal parts and glass wall into the bulb so as to allow this gas to be absorbed by the softening material. Several treatments may be necessary, but once the spark gap has begun to increase it is a simple matter to attain any degree of desired hardness. Frequently it will be found that tubes will show almost no change immediately after treatment but become much harder from one to twenty-four hours after. If at the end of twelve to twenty-four hours the tube does not tend to become harder, another treatment is indicated. Tubes hardened by this method will keep their vacuum and gap indefinitely, as shown by their daily use in the x-ray labora-

tory of Mount Sinai Hospital, New York City. The tendency of these tubes upon standing is to become progressively harder.

We have not had experience with tubes containing metallic regulators as softening devices, therefore cannot state whether this method is applicable to such tubes. Our experience has been limited to tubes containing hygroscopic material.

CONCLUSION

In conclusion, we feel that both theoretical considerations and practical results justify us in stating that *gas tubes containing some hygroscopic material such as asbestos packing can be hardened rapidly and conveniently by cooling the softening device by an ethylchloride spray.*

TABLE I

TUBE	SPARK GAP BEFORE HARDENING	SPARK GAP ONE HOUR AFTER HARDENING	SPARK GAP 24 HOURS AFTER HARDENING	SPARK GAP 48 HOURS AFTER HARDENING	REMARKS
1	Less than 2 in.	3 inches	5 inches	7 inches	Soft since 1916
2	Less than 2 in.	No change	4 inches	7½ inches	Soft since 1916
3	Less than 2 in.	No change	6 inches	6 inches	Soft since 1916
4	Less than 2 in.	3 inches	6 inches	6½ inches	
5	2 inches	5 inches	7 inches	7 inches	Helium
6	Less than 2 in.	4 inches	7 inches	8 inches	Accidentally Softened. Returned quickly
7	2 inches	3 inches	4 inches	5 inches	Helium
8	Less than 2 in.	No change	2¾ inches*	5 inches	
9	2 inches	No change	4½ inches	4½ inches	
10	Less than 2 in.	3 inches	3½ inches	5 inches	
11	Less than 2 in.	4 inches	5½ inches	5½ inches	
12	2½ inches	3½ inches	5 inches*	7½ inches	Old target. Focal spot cracked.
13	Less than 2 in.	2 inches*	6 inches	6 inches	
14	Less than 2 in.	2¾ inches	5 inches	6 inches	
15	2¼ inches	No change*	4 inches	5½ inches	
16	2¾ inches	4 inches	7 inches	7 inches	
17	4 inches	5 inches	5½ inches	5½ inches	
18	5 inches	5½ inches	6½ inches	6½ inches	
19	Less than 2 in.	2 inches	4½ inches	5 inches	
20	Less than 2 in.	6 inches	6½ inches	6½ inches	
21	Less than 2 in.	No change*	2 inches*	4 inches	
22	2 inches	No change*	3½ inches*	7 inches	
23	4½ inches	5½ inches	6½ inches	7½ inches	
24	Less than 2 in.	No change*	No change*	4½ inches	
25	2¾ inches	2¾ inches	3½ inches	6 inches	

*Denotes re-spraying after testing tube.

REMARKS ON THE TECHNIQUE OF THE ROENTGEN EXAMINATION OF THE KIDNEYS

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THE technique which I am about to set forth in more or less laborious detail is by no means all my own, if indeed I can lay claim to any of it. It is mostly patched together from the oft-repeated suggestions of others. The only justification for the use of the little word "my" which frequently sets the rest of us on edge, is a certain grouping of the essential and indispensable factors of success, an exacting and persistent carrying out of every detail, together with full knowledge of, and an abiding faith in, the results that can be achieved when this work is done in the right way.

In doing kidney work our chief aim should be to produce plates showing the whole kidney outline clearly, unmistakably and without the aid of the imagination. Such a plate will possess the maximum of diagnostic value in every condition for which we are called upon to examine the kidneys. If the kidney substance shows clearly, denser substances will show much more clearly.

FIG. 1. NORMAL KIDNEY—RIGHT. NOTE CALICES UNINJECTED.

To make such plates with uniformity and

certainty there are certain points of technique which are absolutely essential. I will mention them somewhat in the order of their importance, though after the first, there is little choice as to which should be placed second, third or fourth in order of importance. Easily of first importance is the quality of the ray used; second, correct and adequate compression; third, preparation of the patient; fourth, control, real control, of the patient's respiration.

Kidney plates should be clear, soft and sharp, suggesting under-exposure rather than over-exposure. No black should anywhere appear on the plate. Such a plate cannot be made if the tube is excited by a current of high voltage. In actual practice I use a 3 to 3½ inch spark gap, 35 milliamperes, and an exposure varying from four to eight seconds depending upon the size of the patient. The time only is varied.

Second in importance and very much more difficult to obtain are proper compression of the patient and correct placing of the compression cylinder. For accuracy and ease of manipulation it is almost essential that the tube-stand be attached to the table, moving freely and easily at the side. With this type of table the tube-stand can be fixed so rigid that there is no possibility of any movement of the patient altering the position or angle of the tube. It is quite essential that the end of the compression cylinder be equipped with a convex aluminum cap. This sinks deep into the soft parts and displaces denser material; it also sometimes forces aside gas which may

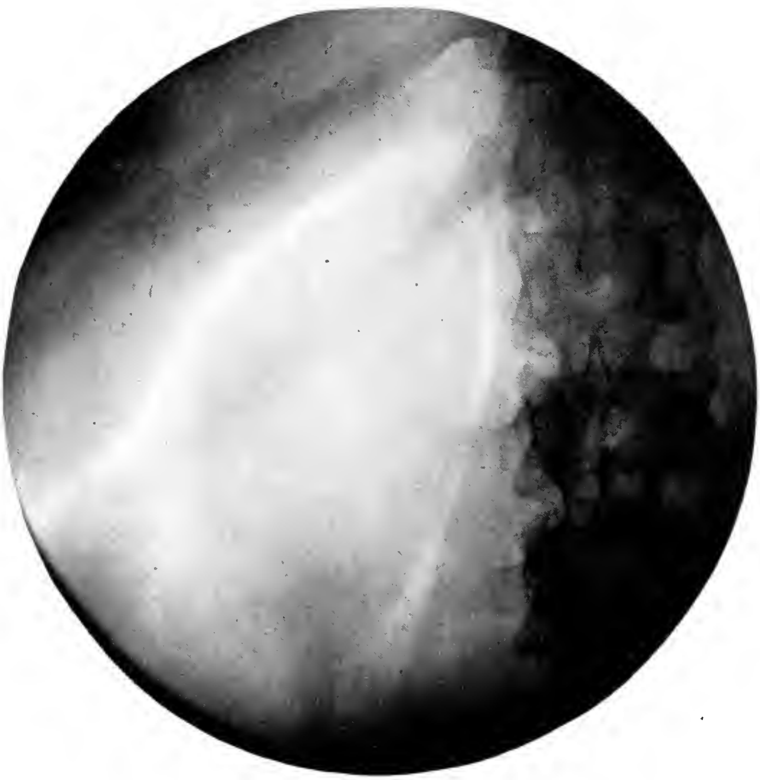

Fig. 2. Normal Kidney Outline—Left Kidney.

be present in the colon. If the diameter of the cylinder is more than 5 inches at a distance of 13 inches from the target, the plate will be very little clearer than if no cylinder at all were used.

Again, in practice, I proceed as follows: The patient's knees are flexed. An 8 by 10 plate is placed crosswise under, say, the right side, so that its lower edge is about even with the umbilicus. The tube is then adjusted over a point midway between the umbilicus and the ensiform cartilage. The cylinder is then tilted between 5° and 10°, so as to point toward the right. At this angle it is lowered onto the patient slightly to the right of the median line, brought down with a fine adjustment device as tight as the patient will easily allow, and fixed so that it cannot be raised. The cylinder is now tilted about 10 to 25 degrees to point up under the ribs, and fixed in this position, and pushed up under the ribs as far toward the patient's head as he will allow, and fixed in this position. Finally, the tube and cylinder, sliding on the horizontal arm of the tube-stand, are moved as far towards the right as the patient will allow, and fixed in this position. This last movement will pull the ribs over to a considerable degree and it is necessary to instruct the patient not to turn toward the right side, and not to allow his back to slip on the table with an inclination to follow the movement of the tube. With everything fixed and rigid, the exposure is made.

Fig. 3. Normal Kidney Shadow—Left.

While the preparation of the patient is important, it is not essential in every case.

In patients who are not constipated or subject to gas formation in the colon, the examination may be made successfully without previous preparation; however, it is best in every case, when circumstances permit. This preparation consists of a thorough laxative the night before and an enema, as nearly as convenient, immediately preceding the examination. The importance of this cannot be too strongly emphasized in many cases. The kidney outline cannot be clearly brought out if there is a big gas pocket in the colon immediately over it.

In this connection a word as to the kind of patient who is most favorable for this work might not be amiss. The most favorable type is the rather fat, small individual. In such a case we have an ample bed of perinephritic fat much less dense than the kidney substance and supplying the contrast that is so desirable. For this reason even large, fat patients often prove easier than small, lean ones. But, large or small, fat or lean, the kidney outline can be brought out.

It has been customary to dismiss the point of the patient's respiration simply by saying, "instruct the patient to hold his breath during the exposure." If the doing were as easy as the saying, it would need no further comment, but it is not. Many patients find it quite difficult to stop breathing entirely, even for five or six seconds. Many think that they are holding their breath when they are not. Place a mirror on the abdomen of such a

Fig. 4. Kidney Injected—Catheter in situ. Note the Blurring Effect of Incomplete Respiratory Control.

patient, and while he is trying to hold his breath the reflection from the mirror will continue to sweep back and forth upon the ceiling. Such patients need instruction in holding the breath and close watching during the exposure.

The kidneys move more than we realize during respiration. This movement is from one-half to one and a half inches. A movement of only one-quarter inch will convert the shadow of a round stone into a long one, cause us to miss a small stone entirely, and completely obliterate any well-defined kidney outline.

FIG. 5. KIDNEY OUTLINE, WITH STONE IN LOWER POLL. CATHETER IN SITU. NOTE THE SHARPNESS OF THE CATHETER SHADOW, INDICATING COMPLETE RESPIRATORY CONTROL.

SUBPHRENIC PNEUMOPERITONEUM*

Produced by Intra-uterine Insufflation of Oxygen as a Test of Patency of the Fallopian Tubes in Sterility and in Allied Gynecological Conditions

By I. C. RUBIN, M.D., F.A.C.S.

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THE production of pneumoperitoneum by the method of insufflating the uterus with oxygen is intended to serve the specific purpose of testing the patency of Fallopian tubes. When the tubes are patent the gas passes into the peritoneal cavity, establishing an artificial pneumoperitoneum. This is detected by fluoroscopic examination. When occluded, the gas fails to reach the peritoneal cavity. In this failure to establish a pneumoperitoneum by the uterine route is furnished a fact of diagnostic value important particularly in the problem of the sterile woman.

Comparison of the Abdominal and Uterine Method of Producing Pneumoperitoneum.—This method cannot enter into competition with the production of pneumoperitoneum by abdominal puncture because of certain natural and pathological limitations. 1. It is obviously limited to women. 2. It is not applicable to all women, particularly the unmarried. Conditions such as pregnancy, menstruation and pelvic inflammation contraindicate for the time being its use. The method by abdominal puncture may be employed in the presence of nearly all these conditions without regard to uterine function. In cases where the uterus may be properly insufflated and the tubes are patent, it is of course possible to fill the peritoneal cavity with any desirable quantity of oxygen, in which case it may also serve as an aid in general abdominal diagnosis. This I have done in several cases at the request of colleagues in the medical and surgical services of Mt. Sinai Hospital. It may only be mentioned here that it can be done very simply without occasioning any appreciable sense of discomfort to the patient and involves no special surgical experience. It is not my purpose to advocate it either to substitute or to supplant the abdominal puncture method for general abdominal diagnosis. I am interested chiefly and practically in the aid it may render in clearing up the etiology of sterility in women.

In the problem of sterility a negative result is of equal importance with a positive result. Both prognosis and therapy depend upon whether Fallopian tubes in any given case of sterility are open or closed. I have elsewhere [1] pointed out that if we could demonstrate beforehand that the tubes are occluded a great many operations on the cervix of the uterus would not be undertaken. Instead of operating in such case upon the lower end of the uterus with a fruitless result, the patient remaining sterile and hoping against hope of becoming a mother, proper therapy would consist in immediately opening the abdomen with the object of freeing the tubes and doing some adequate plastic operation. Such operations have not infrequently resulted in curing sterility. Whether or not this type of operation is consented to, we are at least in the position to tell the patient from the very outset what her chances are for becoming a mother. Much time may be saved for those women who would gladly submit to a corrective operation at the very beginning were we in a position to locate the obstacle to conception at the true portion of the genital canal.

A word as to the *limitation of the abdom-*

[1] *Journal American Medical Association*, Sept. 4, 1920. Paper read before the Section of Obstetrics and Gynecology at the seventy-first session of the American Medical Association.

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

inal puncture method and its ability to demonstrate patency or occlusion of the tubes. It has been possible to outline the uterus, tubes and ovaries, inclusive of tumors of these organs and inflammatory conditions in the pelvis, by forcing the oxygen through the abdominal puncture into the pelvis in the extreme Trendelenburg posture. In a very limited number of instances one may be fortunate enough to succeed by this method in demonstrating the fimbriated end of both tubes distinct from the ovaries and the uterus. In the absence of adhesions one might assume them to be normal. In the presence of tumor masses it is not so easy to distinguish between the tube and ovaries, nor are we always fortunate enough in separating the shadows of distorted and dislocated tubes from adherent and overlying ovarian tumors, or from pelvic abscesses and tumors of the uterus. One need but recall in this connection the difficulty of distinguishing structures in pelvic inflammations when the abdomen is opened. Also the demonstration of bilateral masses by the shadowgram does not preclude actual patency of one or both tubes. It is absolutely possible to determine this fact by the method of intra-uterine insufflation of oxygen. I have on several occasions been able to demonstrate patency of the tubes in the presence of bilateral adnexal masses and at the same time establish that the lesion involved the ovaries alone. If in the presence of pelvic masses the gas fails to produce a pneumoperitoneum it may be safely concluded that the tubes are diseased and occluded at some point of their lumen.

Whether or not gross lesions in the pelvis may be more accurately outlined and interpreted by pneumoroentgenograms than by physical examination, *the matter of patency or non-patency is specifically established by the patency of the tubes to oxygen.* This point has hitherto been a matter of clinical speculation defying the skill of the expert in physical examination. The only way by which this fact could formerly be established was by actual laparotomy with inspection of the tubes, palpation, probing them with a sound and inflating them from the fimbriated end, a practice advocated notably by English gynecologists.

The value of the method as a practical test in cases of sterility may perhaps be illustrated by the following two cases:

Case I. A patient married three years and sterile; upon pelvic examination she was advised to be operated, and a dilatation of the cervix, curettage and stem pessary insertion were subsequently performed. Four days following this operation I was requested to test the patency of her Fallopian tubes. The method employed by me resulted in failure to establish a pneumoperitoneum. Laparotomy the same day revealed the fact that both tubes were closed at the fimbriated end. They were only slightly distended, their walls were flaccid and they were surrounded by soft, cobweb adhesions—in other words an old standing bilateral hydrosalpinx. The operation on the cervix in this case was certainly fruitless and could have been avoided by a preliminary examination with oxygen.

Case II. A patient married five years, sterile, no pelvic lesion demonstrable to account for the sterility. Insufflation of the uterus with oxygen on three occasions (with and without pressure control) failed to establish a pneumoperitoneum. She was advised to have a laparotomy performed in the endeavor to remedy the occlusion. This advice she apparently did not heed because some months later she had a curettage and Dudley operation, following the advice of a physician who assured her that to become a mother all she needed was to have her womb "stretched." The lesion in her case could not have been very pronounced at any time, eluding detection by the palpating finger, because the operation was performed by a gynecologist of considerable experience and one who must have concurred in the opinion of the general practitioner.

Safety of the Method and Advantages Over Exploratory Laparotomy.—Notwith-

standing theoretical objections, all of which I have carefully considered in first contemplating the method, it has proved in my hands an absolutely safe procedure. Thus far I have had occasion to employ the method in 150 cases. As some of the cases were re-examined for purposes of corroboration, the total number of examinations was 170. In no case was there any evidence of injury or of infection. The cases were all observed carefully for a period of several months.

Compared to an exploratory laparotomy for the specific purpose of determining the patency of Fallopian tubes, it has several superior advantages, not the least of which is the economic advantage of saving the patient from the usual period required for post-operative convalescence. The method may be employed as a routine measure in one's office and the patient loses no time in laying up, has none of the discomforts and morbidity attendant upon a laparotomy. I am not discussing the question of mortality, assuming that that is practically nil in exploratory surgery. The method proposed by me should never result in mortality. The one theoretical possibility of fatality resulting is offered by the occurrence of embolism. This I have satisfied myself, by experimentation upon the extirpated uterus and in the living animal by direct intravenous insufflation of oxygen, can be dismissed from practical consideration. This accident and that of infection have not occurred in my series of cases, and infection should never occur when the procedure is adopted in properly selected cases and for the specific object of testing the patency of Fallopian tubes.

Contraindications.—The uterus should not be insufflated with oxygen in the presence of pus pouring down from the cervix, in the presence of fever caused by pelvic inflammation, in the presence of acute bartholinitis, urethritis or vaginitis. It is not advisable to use it during menstruation or any irregular uterine bleeding.

Ideal to be Sought in the Use of the Method.—By this I mean that we should be able to employ it in the office as a routine procedure for diagnosis comparable to cystoscopy and ureteral catheterization, occasioning no more and possibly less pain and discomfort than obtains in the urological examination. One of the chief aims is to make the method tolerable to the patient. It should not require the use of an anesthetic. So far I have not had to resort to any. It should take a short time, a minute or two, at the most three. It should be followed by very slight symptoms and not interfere with the daily duties and usefulness of the patient. To accomplish this, it is necessary to produce what might be called a miniature pneumoperitoneum confined in the erect posture to the subphrenic space. The smallest amount of oxygen sufficient to show distinctly through the fluoroscope should be injected. I have found in developing the method that from 100 to 150 c.c. of oxygen suffice to establish the subphrenic pneumoperitoneum. The most favorable time for the test is in the post-menstrual stage, in the interval of apparent functional quiescence.

Technique.—The armamentorium consists of an oxygen tank connected with a water bottle, the rubber stopper of which is perforated at three points through which bent glass connecting tubes pass. (Fig. 1.) One of these glass tubes is connected directly with the oxygen tank and dips down below the water level. The two other glass tubes dip down one or two inches and do not reach the water level. One of these is attached by rubber tubing to a mercurial manometer and the other is attached in the same way to the metal cannula. This metal cannula is of the Keyes-Ultzman type and is perforated at the tip by several small apertures. (Fig. 1.) A single tenaculum or bullet forceps, a uterine sound, a dressing forceps and bivalve vaginal speculum complete the apparatus. A rubber urethral tip is fitted over the metallic cannula to a point 1½ to 2 inches away from the cannula tip.[2]

[2]Recently at the suggestion of my friend Dr. E. D. Oppenheimer I have adopted a simple device for measuring the volume of the gas and hope to describe it in the near future. It is made by courtesy of Wallace & Tiernan, 349 Broadway, New York City.

The volume of gas entering the uterus and eventually into the peritoneal cavity may be measured by displacing water and taking the time—interval measured in minutes. The average amount of water displaced should not exceed 250 c.c. per minute nor be less than 50 c.c. per minute. The rate of flow determines the pressure. The rapidity with which this rises I have found to be best limited to a 10:15 second interval for 100 millimeters mercury. At this rate from approximately 250 to 150 c.c. of oxygen is released per minute. This is determined previously by pinching the rubber tubing with the needle valve shut, allowing the gas to pass through at the rate fixed by the water displacement. With the gas flowing at this rate it may now be introduced into the uterus. The cervix is wiped clean and painted with iodine. A single tenaculum hook grasps the anterior lip. The cannula is introduced into the uterus well above the internal os and the urethral rubber tip is pushed well into the external os so as to render it air-tight. The gas is allowed to escape during this maneuver through the needle-valve release; the pressure is therefore atmospheric. As soon as the cannula is well secured within the uterus the needle valve is closed, allowing the oxygen to be insufflated within the uterus. Almost instantly the pressure rises. When the cannula is fixed within the uterus the patient is raised in slight Trendelenburg position and the vagina is filled partly with water to show any escaping gas from the cervix. This is not always necessary and should only be done in doubtful cases.

Pressure Reading in the Case of Patent Tubes.—The mercurial pressure rises to at least 40 mm., more often to from 60 to 100, with a slight momentary fluctuation possibly at that point, when it drops quite sharply 20 to 40 or even 60 points, which latter level it maintains more or less until the cannula is removed. The time required for the pressure to reach its maximum point according to the recommendation as above described is usually 15 to 25 or 30 seconds. The rest of the time, say 30 seconds to 45 or 60 seconds, is allowed for actual inflow into the peritoneal cavity.[3] This will depend upon the time interval required for the initial rise to the maximum on the one hand and on the other upon the size of the individual.

If the individual is narrow-waisted and thin she does not require as much gas to produce the subphrenic pneumoperitoneum as would an ample-waisted patient. These

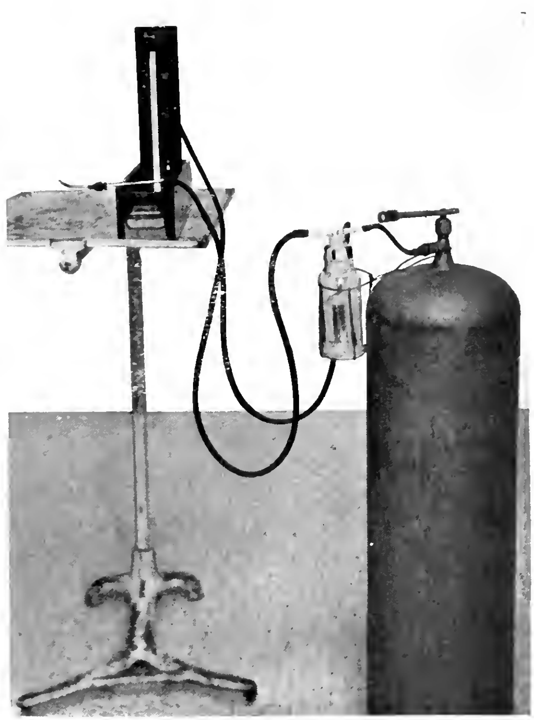

Fig. 1. The Apparatus Assembled. Note the Relief (Needle) Valve. This relief valve may be at any point in the outlet tube in case the tycos type of manometer is employed.

matters one can learn to gauge after some experience. No hard and fast rule can be laid down for these variations. At most they are slight and offer no difficulty. The average amount of oxygen required in a thin individual is from 75 to 100 c.c. In a stout woman it is well to use from 150 to 250 c.c.[4]

Pressure Reading in the Case of the Non-

[3]The siphon meter of the Wallace & Tiernan type records the volume passing through automatically.

[4]When CO_2 is employed the quantity may because of its rapid absorption exceed these figures several fold.

Patent Tubes.—The pressure rises steadily, reaching 200 within 30 to 45 or 60 seconds. The pressure should not be allowed to exceed 250. It is maintained at between 200 and 250 for at least another minute if possible. This can be done by regulating the needle valve to permit a slight escape of the gas. In my experience so far a pressure of 200 or more, provided the rate of flow does not exceed 250 c.c. per minute, proves fairly conclusively the presence of tubal obstruction. This may of course be within the uterus itself, the blockade being at the uterine ostiae of the tubes, or it may be at any point along their lumen. When the rate of flow exceeds 250 c.c. per minute the initial rise may occasionally read 200 mm. or more before the gas passes into the Fallopian tubes and thence into the peritoneal cavity. The physics thus expressed is only from practical tests. Exact computations have as yet not been made.

Fig. 2. Subphrenic Pneumoperitoneum, 250 c.c. of Oxygen Insufflated through the Uterus and Fallopian Tubes. Diaphragm distinct on the right side; not visible on the left.

Fig. 3. Subphrenic Pneumoperitoneum, 1500 c.c. of Oxygen Insufflated through the Uterus and Fallopian Tubes. Diaphragm distinctly visible on right and left sides. Abdominal viscera displaced to a considerable depth. For the purpose of demonstrating patency of the Fallopian tubes one-fifteenth of this amount is sufficient and satisfactory in the majority of cases.

Symptoms. 1. *During the Oxygen Insufflation.*—The introduction of the cannula is attended in most cases with slight pain. Grasping the anterior lip of the cervix by the single tenaculum hook is noticed scarcely, if at all, by the patient. The actual insufflation in the patent cases seldom causes pain. When the initial pressure exceeds 100 the patient may complain of a sensation of fullness or bearing down or occasionally she may feel as if she were unwell. In the non-patent cases with the pressure rising to 200, cramps are occasionally complained of, now in the suprapubic region and now in one or both sides. Since the time required for insufflation is the short interval of one or two minutes, practically every case can tolerate it. I have had practically no failure due to intolerance during the examination. A ner-

vous patient will sometimes defeat the completion of the test, but even she can be reassured and will submit to it at another time. That will happen once in 50 or 100 times.

2. *After the Oxygen Insufflation; Fluoroscopy. In the Patent Cases.*—Inasmuch as the patient is instructed to stand up immediately on withdrawing the uterine cannula, the oxygen gas rises almost instantaneously to the region of the diaphragm. It occupies the subphrenic space for a depth of 1/4 to 1 inch or more depending upon the amount insufflated. (Fig. 2.) Within two or three minutes if not sooner (just as soon as the patient can be set up before the fluoroscopic screen) the transparent "gas" area may be seen under the diaphragm. The liver on the right side is seen displaced in a downward direction. Not infrequently the gas may be localized to one or the other side, but as a rule the diaphragm may be seen lifted above the underlying abdominal viscera from right to left. It is discernible as a transverse septum and is unmistakable. When the subphrenic pneumoperitoneum is not at once visible the patient is instructed to lie on her right or left side for a few minutes, after which the gas will show clearly on one side or the other.

It is not necessary for the purpose of testing the patency of Fallopian tubes to fill the peritoneal cavity with a large volume of gas in sufficient quantity to "visualize" the abdominal viscera, as in Figure 3. The symptoms in such a case are rather distressing and this is obviated by reducing the pneumoperitoneum to its diminutive. With 75 to 100 c.c. of oxygen under the diaphragm the secondary symptoms are almost negligible. Slight sticking pains between the shoulder-blades or in the shoulders themselves are noticed by the patients. There is no abdominal distress, and if at all present it amounts to a slight sense of discomfort about the diaphragm. The vast majority of the patients leave the office and continue in their ordinary daily routine. Some patients may require to lie down with feet elevated for a few hours. As, according to Alvarez, carbon

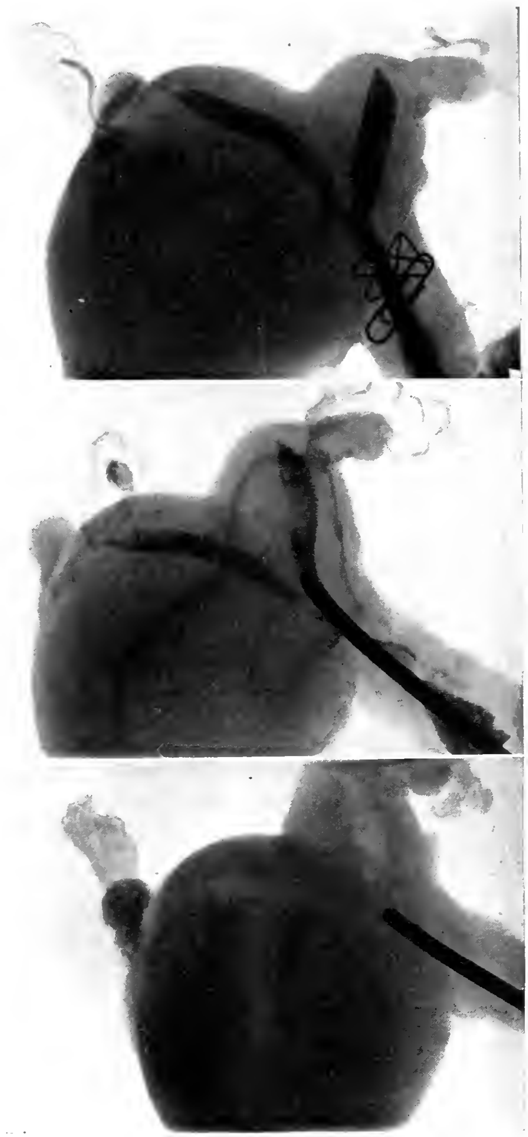

Fig. 4. A Bicornuate Uterus. Thorium injection. The tubes are closed by a ligature at the fimbriated end. Note the definite clubbed outline of the tube at point of ligature and the narrow caliber of the intramural portion.

Fig. 5. The Same Specimen as in Figure 4. Skiagraphed during thorium injection with the ligature removed allowing the solution to escape through the fimbria. Note the irregular and overlying shadows.

Fig. 6. Skiagraph of the Same Specimen as in Figures 4 and 5. Oxygen injection. Note the faint shadows in the horns of the uterus and the absence of any contrast shadows within the Fallopian tubes.

dioxide gas is more rapidly absorbed than oxygen, it may be well to use it and reduce the secondary symptoms to a negligible minimum.

Immediately on withdrawing the uterine cannula there may be a slight regurgitation of oxygen with a slight oozing of several drops of blood that is readily checked by a sponge applied to the cervix. It is negligible and gives no further trouble. By selecting the post-menstrual period for the test one can avoid even this slight oozing.

In the Non-Patent Cases.—Beyond the temporary discomfort produced by the insufflation there are no further symptoms. The cramps may continue for a minute or two or perhaps five and then subside. None of the referred shoulder pains are complained of and there is no epigastric oppression. The oozing is almost as slight as in the case of patent tubes; the oxygen regurgitation may be more evident. The non-patent tube cases are perfectly comfortable after the test and leave the office to go about their duties as freely as before.

It is well to mention here that I have made it a rule to repeat the test at least once in the non-patent cases to check up the findings at the first examination. With the apparatus properly adjusted in each case the findings will be found to corroborate each other at the second test. Occasionally, however, there may be an error in technique which will invalidate the conclusion. Most scrupulous attention should be given the possible points of leakage along the entire apparatus.

FIG. 7. CASE OF ABLATED TUBES; LARGE UTERUS—40 C.C. OF OXYGEN INJECTED INTO THE UTERINE CAVITY. This is seen transversely pear-shaped. The speculum, cannula and Thomas pessary are also seen.

FIG. 8. SAME CASE AS IN FIGURE 7. 40 C.C. THORIUM INJECTED INTO THE UTERINE CAVITY.

While in the positively patent cases there may have been some regurgitation, nevertheless when this occurs and the gas does not enter the peritoneal cavity we are left in doubt and must, if need be, repeat the test several times. If regurgitation takes place each time it is highly probable that there is an obstruction within the uterus which is responsible for it. On the other hand, oxygen may escape from the cervix and a sufficient quantity nevertheless reach the peritoneal cavity as may be determined by the fluoroscope.

Anatomical Consideration in Relation to the Test.—The ideal case for the test is one in which there is no thick tenacious plug present, in which the external os is round

and intact, the uterus not sharply angulated. In such cases the cannula (ordinary size) enters easily and obturation is more perfect. When the uterus is sharply flexed forward or backward it is necessary to shape the cannula accordingly so that it may enter the uterine cavity to a point above the internal os. When the external os is gaping and torn as obtains in certain cases of relative or secondary sterility it may be necessary to secure better obturation by grasping the two lips of the cervix with a bullet forceps. The internal os, however, is intact even in these cases and as the cannula is introduced beyond it the ordinary cannula insures satisfactory obturation. A mucus plug should be cleaned out and the cervical canal painted with tincture of iodine.

When the external os is narrow it is necessary to use a cannula of correspondingly smaller caliber or it may be advisable first to dilate it gently to proper width.

Occasionally obstruction is encountered near the internal os. Here of course the test cannot be carried out. This is an incidental finding which has particular significance in the problem of sterility for that given patient. In such case it is first advisable to overcome the stenosis by proper dilatation and then later on the oxygen insufflation may be tried. I have had two such cases in my series.

Uterine Insufflation of Oxygen Compared to Intrauterine Injection of Solutions Opaque to the X-Ray as a Test of Tubal Patency.—My experience with the injection of solutions opaque to the *x*-ray included collargol, thorium and bromide. All of these are useful when the tubes are occluded. (Figs. 4 and 8.) When the tubes are patent the roentgenograms are not uniformly satisfactory because the solution escapes into the peritoneal cavity and not enough of it is left to show in the tube lumen. (Fig. 5.) Collargol leaves deposits in the tubes which may or may not be absorbed. Thorium and bromide in solution do not leave precipitates. Peritoneal irritation by chemical action with consequent adhesions is a possibility to be borne in mind. Whether or not this may be the case, an objectionable feature to the use of the solutions is the uterine colic, accompanying and following the injection. Patients do not tolerate this so well. In this one respect the oxygen insufflation has a particularly superior advantage. Any residual oxygen within the uterus is immediately expelled with the removal of the cannula. The other advantage of no less importance is that the oxygen is readily absorbed by the tissues and does not leave irritative precipitates. Only exceptionally will one encounter a uterus that may be called irritable to the oxygen. It is more apt to be in a very nervous woman. In my experience with the oxygen insufflation I have succeeded in completing the test in every case, although in two instances I had to defer the test for another time owing to apprehension on the part of the patient. It is conceivable however that in cases of endometritis and perimetritis of more recent date the uterus will be tender to the manipulation.

Oxygen does not show in the tubes when patent. In the anatomical specimen it may show very faintly in the skiagraph (Fig. 6) when the tubes are ligated at the fimbriated end but not in sufficient density to appear in the living subject where the contrast is obliterated by neighboring shadows, etc. Occasionally in a case where both tubes have been removed and the uterine cavity is large, having a capacity of 40 to 50 c.c., one may succeed in getting a good outline picture with oxygen. I have had one such result. (Fig. 7.) Our experience in attempting to demonstrate the oxygen in uteri during the injection with the exception of this one case has so far not been satisfactory although we have not made a persistent effort in this direction.

Conditions in which the Intra-uterine Oxygen Insufflation Method Has Been Found Useful.—1. Primary and absolute sterility of several years' duration with no gross lesions ascertainable. This is the ideal group for the test.

2. Sterility of long standing where pelvic

masses are palpable and clinically diagnosticated as fibroids or "chronic diseased adnexa." The test shows whether or not the tubes are open.

3. Cases in which one tube was removed for inflammatory disease or for unilateral ectopic to determine the normality of the lumen of the residual tube.

4. Cases in which there is a history of an attack of appendicitis with peritonitis in the premarital or postmarital state to exclude tubal occlusion by a residual adhesive peritonitis.

5. Cases following a pelvic exudate or abscess with or without operation and where apparent resolution has taken place and yet sterility is complained of.

6. To test the probity of the tubes in cases where tubal ligation was done with the object of permanent sterilization.

7. To test the continuity of the genital canal in cases where the conservative operation of myomectomy, single or multiple, was done in the hope of relieving sterility.

8. To test the result of plastic operation on the tubes in cases of bilateral salpingostomy.

A detailed account of these results will be taken up in a clinical consideration of the problem of sterility.

CONCLUSION

The method of intra-uterine oxygen insufflation to produce an artificial pneumoperitoneum establishes the fact of patency or occlusion of Fallopian tubes. Under manometric and volumetric control it is a scientific, diagnostic procedure and may be employed with safety to determine the mechanical factor involved in the etiology of female sterility. For this purpose it obviates the necessity of surgical exploration and is specific.

As the fact of tubal patency is in most cases primarily a matter for speculation, its scope for general abdominal diagnosis as compared to that offered by the direct abdominal puncture metohd is necessarily limited. In cases where the tubes are patent, however, a pneumoperitoneum of any size may be produced by the uterine route.

For the definite object of establishing tubal patency by intra-uterine insufflation, only a diminutive amount of gas is necessary because the result desired is to produce a localized subphrenic pneumoperitoneum which shall be followed by scant if any symptoms. The vast majority of the patients tolerate this method very well and it may be employed as a routine office procedure. The use of carbon dioxide instead of oxygen will diminish the symptoms following insufflation almost to a vanishing point. It is well however to bear in mind the primary object of the test and to apply it only in cases properly suited for its use. In these it has proved of great diagnostic and prognostic value.

In 150 cases, with a total of 170 examinations, there have been no untoward sequelae.

THE DETECTION OF RETROPERITONEAL MASSES BY THE AID OF PNEUMOPERITONEUM

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ST. LOUIS, MISSOURI

THE wider use of pneumoperitoneum as an aid to radiological diagnosis of abdominal conditions is fast bringing the subject from the stage of generalities to that of more special methods of examination.

The number of experiences encountered, even in the fifty pathological cases which we have had, is so large that it would seem more advisable and probably be more profitable to consider one of the groups into which these cases fall rather than to undertake a discussion of the subject in general. I shall, therefore, confine this paper to one of the groups of cases in which we have found this method of great aid; I refer to the detection of retroperitoneal masses.

Early in our experience with pneumoperitoneum, we encountered a case which proved to be of great value to us in developing a technique for the detection of retroperitoneal masses. I shall outline the case, as it presented itself. B. C., a well developed, colored male, age twenty-six, presented himself, with a slightly tender, very hard, smooth mass in the lower right quadrant of the abdomen. The case was the occasion of some dispute among the staff, as to whether the mass was attached to the kidney or not, and a pneumoperitoneum examination was made to try to determine its origin. By the ordinary antero-posterior plate, it was found that the mass was entirely free from both kidneys, and that it extended downward to the pelvis and across the midline, causing nearly as large a mass, as yet undiscovered, on the left side. In an effort to determine the relation of this mass to the ureter an injection of thorium was made into the kidney pelvis and a plate was made showing the smooth gentle curve of the ureter. A second plate was then made while exerting upward and inward pressure on the mass with a cone, and the radiograph showed a distinct kinking of the ureter, suggesting that the mass was retroperitoneal and that the ureter passed anterior to it. Destruction of the bodies of the 4th and 5th lumbar was noted, and the possibility of the mass being a tuber-

FIG. 1. RETROPERITONEAL POSITION. Patient Prone. Chest and thighs supported on two blocks, allowing the abdominal wall to sag freely without pressure.

cular abscess was at once considered. In an effort to demonstrate the origin of the mass more clearly, the patient was examined in a prone position (Fig. 1), chest and thighs supported on two blocks taking all pressure off the abdomen and allowing the anterior abdominal wall to sag freely between the two supports. The retroperitoneal character of the mass and its complete separation from the kidneys was then clearly shown (Fig. 2), and since the mass originated in the area of destruction of the lumbar spine, the diagnosis of psoas abscess was made, which was confirmed by subsequent developments.

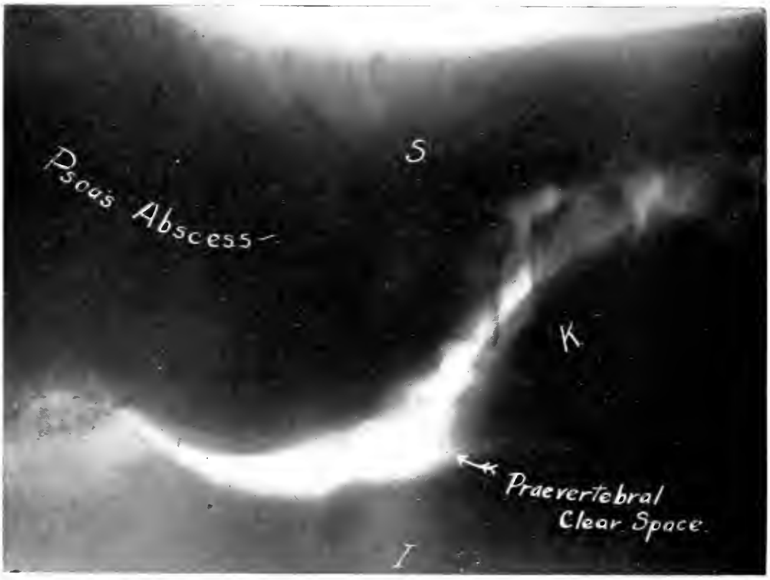

FIG. 2. PSOAS ABSCESS SHOWN IN THE RETROPERITONEAL POSITION ENCROACHING UPON THE PRAEVERTEBRAL CLEAR SPACE.

Since this prone position demonstrated the retroperitoneal origin of the tumor mass so clearly in this case, it was not long before we made a closer examination of its possibilities in other cases. A moment's consideration of the anatomical arrangement in this position may serve better to illustrate the cases which are to follow. (Fig. 3.) It will be noted that if the patient is suspended on two blocks, so as to take all pressure off the abdomen, the belly wall will sag down and all of the intra-abdominal organs with mesenteric attachments will fall forward leaving a clear space between them and the retroperitoneal structures. The liver is attached by the triangular ligament to the diaphragm, and drops forward also, to a greater or lesser extent in different individuals according to the location of this attachment, forming a triangular shadow with the apex at the diaphragmatic attachment. If the individual is normal this space should be clear; if

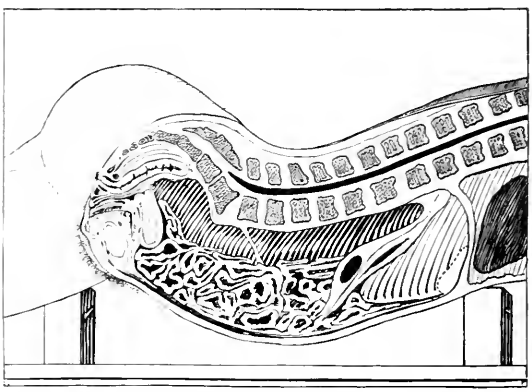

FIG. 3. THE PATIENT, PREVIOUSLY OVERDISTENDED, IS SUPPORTED UPON TWO BLOCKS, allowing the anterior abdominal wall to sag down freely. The intestines and all organs with mesenteric attachment have fallen forward, leaving a praevertebral clear space. Any retroperitoneal mass will encroach upon this clear space.

a retroperitoneal mass is present, this space is encroached upon. Figure 4 shows in a gross way the appearance of a normal individual in the retroperitoneal position. Note that the intestines and all structures with mesenteric attachment have fallen forward and that the prevertebral space is clear and

J. M., white, male, age thirty-two, presents on examination a large tumor mass on the left upper abdomen; not painful and moving only slightly, if at all, with respiration. On inflation the mass was seen to have no connection with the anterior abdominal wall, although it did protrude well forward

Fig. 4. Radiograph of a Normal Individual in the Retroperitoneal Position. Intestines and organs with mesenteric attachment have fallen forward, leaving clear praevertebral area. Encroachment upon this space by a mass originating in the retroperitoneal tissues can be clearly seen.

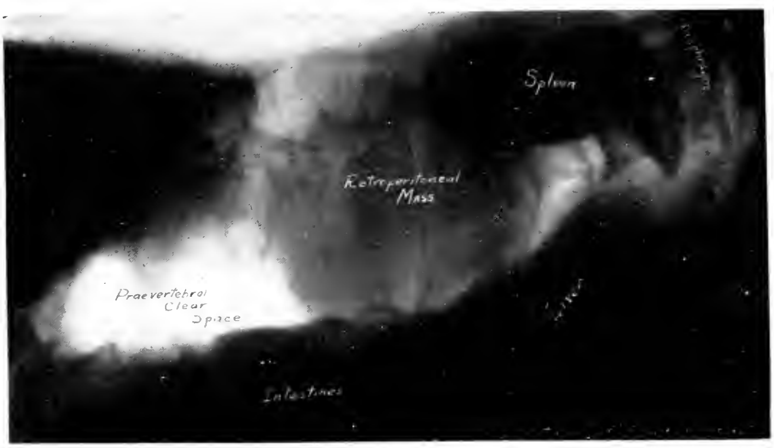

Fig. 5. New Growth of Left Kidney Seen in the Retroperitoneal Position to Encroach upon the Praevertebral Clear Space.

not encroached upon. The liver shadow is seen with its diaphragmatic attachments.

To illustrate the value of this position let us proceed to the second case.

and was represented by a shadow in the middle of the abdomen. An antero-posterior examination revealed the extent of the mass to be even greater than supposed and it

seemed to go down into the pelvis. The liver was shown to be uninvolved.

An examination in the lateral position showed the spleen clearly separated from the mass but the left kidney could not be definitely outlined. In an effort to determine whether the left kidney was involved in the mass, the ureters were catheterized and 20 c.c. of thorium nitrate injected with the result that nothing more than a misshaped shadow appeared within the tumor mass.

To rule out a possible origin from the large bowel, a barium enema was given. The colon was perfectly normal and encircled the tumor without in any way being attached to or compressed by the mass. Lastly, as a final step in the pneumoperitoneal examination, the patient was put in the retroperitoneal position with Figure 5 as a result. The intestines, stomach and all organs with mesenteric attachment have fallen forward. The liver has dropped exceptionally far forward and the only organ which still remains in place is the spleen, which probably is adherent somewhat to the diaphragm, and which may also have been prevented from displacement by the shelf-like projection of the mass. The mass itself can be seen taking origin among the retroperitoneal tissues and extending forward to encroach upon the prevertebral space. Diagnosis of a new growth involving left kidney was made.

FIG. 6. (*Above*) PERINEPHRITIC ABSCESS SHOWING DIFFUSE RATHER EXTENSIVE ENCROACHMENT OF THE MASS UPON THE PRAEVERTEBRAL SPACE.

FIG. 7. (*Below*) LARGE SARCOMA OF KIDNEY SHOWN IN THE RETROPERITONEAL POSITION TO ENCROACH UPON THE PRAEVERTEBRAL CLEAR SPACE TO A VERY CONSIDERABLE DEGREE.

A third instance illustrating the advantage of this position will be seen in the case of M. S., white, female, age thirty-three, who presented on examination a palpable mass in

the right lower abdomen which was very tender both on abdominal palpation and over the back, and was thought to be a movable kidney. Pneumoperitoneum examination revealed a diffuse, hazy mass on the right side below the liver and widely separated from it. Examination in the retroperitoneal position was made (Fig. 6) and a rather extensive obscurity of the retroperitoneal tissues was seen. The liver and all organs with mesenteric attachment have fallen forward, but the spleen is adherent and seen in its position in contact with the diaphragm. The mass encroaches upon the prevertebral space but seems to be more diffuse. Psoas abscess was considered but no carious vertebrae could be found. Tumor of the kidney was thought of, but a plate showing clearly the kidney outlines was obtained and the radiological diagnosis was a probable perinephritic abscess. Operation confirmed this diagnosis.

The fourth case in the study of this method of examination, was likewise very interesting. J. V., colored, male, age nineteen, presented besides an enormous abdominal tumor occupying the entire left side of his abdomen, innumerable small nodules under the skin all over the body. The abdominal mass seemed to move slightly with respiration and on first examination was thought to be the spleen. Antero-posterior view made by the aid of pneumoperitoneum at once showed the extent of the mass and showed its separation from the spleen. The lateral view also showed the mass to be very extensive, with areas of irregular density and an oval, more or less smooth outlined mass at the top. A small stringy-like shadow resembling the kidney pelvis was seen in the midst of the mass and on looking up the records of the case it was found that ten months previously there had been an injection of his kidney pelvis made with thorium nitrate. In this plate his kidney outline showed also very well, but since his complaint was the same it is quite probable that this was at the inception of his disease. The diagnosis was not made at that time. Finally examination was made in the retroperitoneal position (Fig. 7) and a large retroperitoneal mass was found projecting forward into the prevertebral

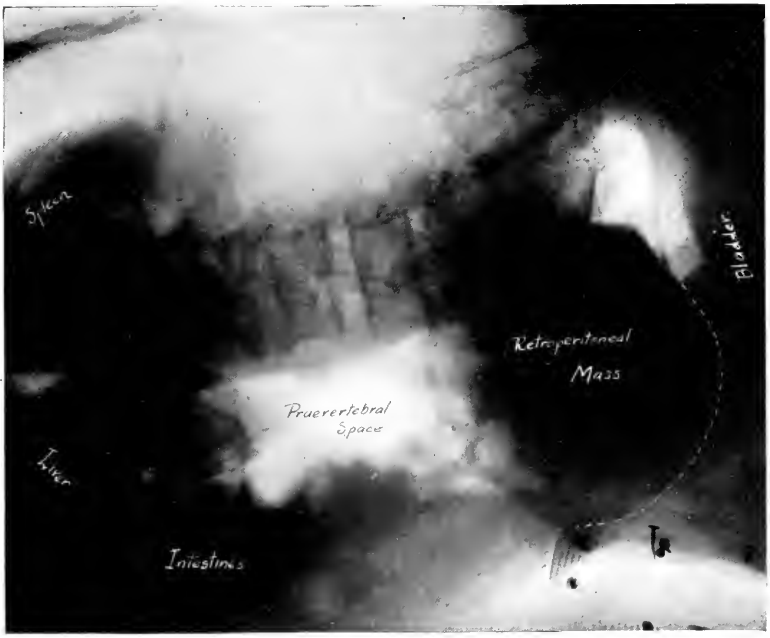

Fig. 8. Retroperitoneal Carcinoma Secondary to Carcinoma of the Bladder Seen Encroaching upon the Praevertebral Space. Note the slightly rotated position necessary when dealing with retroperitoneal masses in the pelvis.

space and almost obliterating it. Diagnosis of tumor of the left kidney was made. Operation and pathological section established the diagnosis of sarcoma of the kidney.

When the pathological process is low down, so that the shadow of the mass falls below the shadow of the innominate bones, the patient, still in the retroperitoneal position, must be rotated slightly towards the side of the tumor, in order to get a view unobstructed by the crest of the ilium.

The following case presents quite clearly the use of the retroperitoneal method of examination in tumors low down or in the pelvis. F. L., white, male, age sixty, presented upon examination a large rounded tumor mass, arising just over the symphysis, and extending to the umbilicus. With frequent voiding of small amounts of urine and tenesmus, the patient looked very similar to one suffering from urinary retention from an hypertrophied prostate. Pneumoperitoneum examination was made and a large mass about the size of a child's head was seen almost completely to fill the pelvis. A dark shadow just above the symphysis was taken to be the collapsed bladder, and on injection this proved to be the case; the mass was separated from the bladder. A barium enema was given and the sigmoid was seen to run over the mass but was unobstructed in its course, and give the impression of a retroperitoneal mass, which had in its growth merely pushed the large bowel forward.

The patient was examined, slightly rotated in the retroperitoneal position (Fig. 8) and a large retroperitoneal mass was found, widely separated from the bladder. No bone destruction of spine or pelvis was found. Cystoscopic examination of the bladder was made and a carcinoma of the bladder was found. Diagnosis of retroperitoneal carcinoma, secondary to a carcinoma of the bladder was made.

To outline briefly the essentials for a satisfactory retroperitoneal examination:

1. It is especially essential when this examination is to be undertaken, to clean out the bowels well, using vegetable cathartics.

2. The patient should void his urine just before examination.

3. He should be given little if any food just prior to the examination.

4. He should be *over-distended* with the inflating medium.

5. He should be sufficiently well supported to exert no pressure on the interabdominal contents.

We have to date used this position in the detection of retroperitoneal masses with continued satisfaction and feel that it will ultimately be of great value for this purpose.

DISCUSSION FOLLOWING SYMPOSIUM ON ARTIFICIAL PNEUMOPERITONEUM

[In addition to Dr. Rubins' and Dr. Sante's articles in this issue of the JOURNAL, the Symposium includes the following: *Pneumoperitoneum of the Pelvis: Gynecological Studies*, by James G. Van Zwaluwenberg, M.D., January issue, p. 12. *Pneumoperitoneum as an Aid in Differential Diagnosis of Diseases of the Left Half of the Abdomen*, by A. F. Tyler, M.D., February issue, p. 65. *The use of CO_2 in Producing Pneumoperitoneum*, by Walter C. Alvarez, M.D., February issue, p. 71.]

DR. LEOPOLD JACHES. The roentgenologic method in connection with Dr. Rubin's work was developed by my associate, Dr. Bendick, and I have seen a relatively small proportion of these cases, but I can assure every roentgenologist here that it is a very easy procedure, that it doesn't take much time. There is no fuss about it. We have very frequently been able to do one or two or three cases between other fluoroscopies. There is absolutely no fuss at all.

I am not as pessimistic as Dr. Rubin is with regard to the possibility of determining which tube is patent and which is closed. It should

not be very difficult to do so fluoroscopically during the time of the inflation.

We have not yet at the hospital a fluoroscope appropriate for this work, but as soon as our Dessane bonnet arrives we shall investigate this phase of pneumoperitoneum.

Dr. J. W. Hunter. I should like to inquire of Dr. Van Zwaluwenberg if pregnancy can be diagnosed by the pneumoperitoneum method unless the head or some of the bones of the fetus are shown on the plates. The reason I ask that is because I did not notice any on the slide which he showed us.

Dr. James G. Van Zwaluwenberg. With regard to the demonstration of pregnancy without the actual demonstration of bony parts of the fetus, I am very optimistic that we shall be able to do this because there must be differences in development and enlargement of the uterus from those of pathological enlargements. We haven't seen a great many of these cases, and I don't know positively whether that is so, but so far we have have had no myomata of the uterus which looked anything at all like pregnancy, and we have plates of one case whose last menstruation was six weeks before the examination, one which Dr. Peterson insisted was pregnancy, and the changes in the uterus are altogether characteristic. That is his opinion. I think there will be very little difficulty in differentiating the distortion of the uterus by a myoma or other enlargement from that of a pregnancy.

To Dr. Stewart, we owe a great obligation, because the idea of the work was directly suggested by some of the plates he showed at Saratoga. The objection he has met, we also are meeting. The Department of Gynecology has been the subject of considerable ridicule for using this method, on the ground that they should be able to make all their diagnoses without it. As a matter of fact, the gynecologist usually knows pretty well what he is going to find when he opens the pelvis, but the fact remains that sometimes he doesn't, as Dr. Rubin's case, in which there were double pus tubes which were not suspected, illustrates. The same sort of thing has happened in our experience. I doubt if the method will ever become routine. We are doing it routinely now until we have established a basis for our opinions, which, at this time, aren't worth a great deal, but I have great hopes that some system of standards can be established which will make this method of real use.

Dr. L. R. Sante. I noticed that Dr. Rubin referred to the pneumoperitoneum showing more on one side than on the other in these cases, and I would like to offer the following as a possible explanation: The mesentery of the small intestine, as we know, is attached on the posterior wall of the abdomen in an oblique position. I wonder if this does not act as a wall, thereby confining the oxygen more on one side of the abdomen or the other depending upon which tube is patent.

Dr. Rubin (closing). I am glad to have heard the explanations of the appearance of the unilateral pneumoperitoneum. I am quite free to say I did not think of all those things. It may very well be, though, because in the beginning we had the patient get off the table on one side or the other, and it is very likely that that occurred, but lately we have had the patient sit bolt upright, so that the explanations given could not be true in that event, and so some other explanation may be necessary. Dr. Sante's suggestion of the slanting mesentery may be true in some cases. On the other hand, as Dr. Stewart explained, the gas takes the path of least resistance and is influenced by the weight of the viscera. It may very well be that sometimes the stomach is heavier than the liver. As a rule, the liver is heavier than the stomach.

About the contra-indications: I would like to repeat them again. The presence of pus in the genital canal, urethra, vagina or cervix, and the presence of fever due to pelvic inflammation are contra-indications. Even though there is an inflammatory process, however, if there is no fever, that lesion is quiescent, and the introduction of 150 c.c. at 200 pressure will not do any harm. It will not do any harm when the fallopian tubes are closed, at least in my experience I have seen no harm result in such cases.

Another thing I want to consider is the theoretical possibility of the formation of embolism. I tested this problem out by actually introducing oxygen into the vein of a dog, and found that 350 c.c. of oxygen injected into the vein did not as it were cause the dog to "turn a hair." Now, if 350 c.c. of oxygen, which is

the very maximum dose which I require for my patients, does not affect a dog by direct intravenous application, it certainly will not do any harm in the human.

I think someone asked about sterilizing the parts. The apparatus I use consists of speculum, tube, single tenaculum hook, and a cannula. These are, of course, boiled. The vagina is wiped clean of whatever mucus may be present, and the cervix touched with iodin.

Dr. L. R. Sante. The wider use of pneumoperitoneum in abdominal conditions has brought the subject from the stage of generalities to that of more special methods of examination. This you have seen to-day in the examination of the pelvic organs, by Dr. Van Zwaluwenberg, in the special examination of the spleen, and also, as mentioned by Dr Tyler, in the detection of abdominal masses. I am glad to hear, also, that Dr. Stewart spoke of the difficulty in differentiating kidney masses, and to see that he showed a case which he infers is a retroperitoneal mass.

When we first started this work about a year ago in the City Hospital in St. Louis, we were greatly handicapped to get a routine technique which would be at once rapid and sufficiently thorough to secure all of the necessary points in the examination. The number of positions in which it was necessary to place the patient was the greatest difficulty we had to overcome. We finally brought into use a type of hospital cart, balanced upon two wheels, so that mere pressure upon the cart at either end would raise or lower the head or feet. This we found most efficient.

When we first undertook this work we followed very closely the technique of the first writers upon the subject, using oxygen as an inflating medium and employing manometers to ascertain the intra-abdominal pressure. Later we used air as an injecting medium and now we use a very simple apparatus. We have dispensed with all manometers and measuring apparatus and use merely a lumbar puncture needle, connected by suitable tubing and connectors to the pump of a Potain aspirator with a Murphy drip interposed as a trap, the small vent hole of which has been plugged. The entire apparatus except the pump is sterilized. The air is not sterilized in any way. We have found that air takes considerably longer to absorb, six to seven days, than oxygen, three to four, but it surely causes less pain; and since we practice deflation on nearly all of our patients after examination, we count the use of air a distinct advantage. We have no difficulty in determining when the needle is in the abdominal cavity by simply listening with a stethoscope on the opposite side of the abdomen for the characteristic sound of the pump.

The routine procedure which we have adopted is to wheel the patient before a vertical fluoroscope while lying on his back.

The needle is inserted, and the patient inflated under the fluoroscope. When sufficient inflation is obtained, the needle is withdrawn. He is then rolled over into the lateral position and examined on each side. After this he is put in the so-called retroperitoneal position, which I will describe later, to determine if any retroperitoneal masses are present. He is then examined in both the dorsal and ventral positions on the horizontal fluoroscope.

One case, which proved to be a retroperitoneal mass, illustrated so well the position I am about to show you for the detection of these masses, that we very soon conceived the idea of using it in many other cases.

The patient presented himself with a mass in the right lower quadrant, very hard and well defined, and of questionable origin. It caused quite a controversy among the surgeons and the genito-urinary man, as a result of which we made pneumoperitoneum examination and fortunately for us, it showed the outline of the mass very clearly, and that it was in no way connected with the kidney. In an effort to determine whether the mass was retroperitoneal, we injected the ureter and kidney pelvis. We noted the smooth outline of the ureter, and then by pressure on the mass with a cone, directing the pressure upward, and inward, were able to demonstrate a kink in the ureter. This seemed to indicate that the ureter ran over the mass, and that the mass therefore was retroperitoneal. We noted, also, the carious appearance of the third and fourth lumbar vertebrae, and suspected a tuberculous abscess. He was then put in this position—chest and thighs supported by two blocks—with his abdomen hanging loosely between; exposing from side to side, we obtained a view of the retroperitoneal and prevertebral space. The mass was retroperitoneal, and proved to be a psoas abscess. You will note that the prevertebral space, which is usually clear, is encroached upon in this way. This case demonstrated so well the advantage of this position

in demonstrating retroperitoneal involvement that we began to utilize it for this purpose in other cases.

This is a diagram merely to show the arrangement of the abdominal organs in this position; the abdominal wall sagging between two blocks permits the intestines and all organs with mesenteric attachment to fall forward, showing clearly the retroperitoneal structures and clear prevertebral space. If there is a retroperitoneal mass, this mass encroaches upon this clear prevertebral space.

The first case is a mass which was not attached to the anterior abdominal wall. In this case, we rolled the patient on the side and showed that the spleen was high up under the diaphragm and entirely independent of the mass. To determine whether the mass was connected with the kidney, we injected the ureter wth thorium, and found an irregular mass in the midst of this area. The colon was injected to see if it was the origin of the mass, but it did not seem to have any connection with it. Examination in the retroperitoneal position, however, disclosed very clearly that the mass was retroperitoneal, and was closely associated with the left kidney. We have used this position successfully in determining the presence and origin of a sarcoma of the kidney; a retroperitoneal carcinoma secondary to carcinoma of the prostate, and closely associated with the kidney; a perinephritic abscess; a psoas abscess; an abscess arising in the seminal vesicle and a retroperitoneal carcinoma secondary to a carcinoma of the bladder.

I feel that with more extensive use this position will prove of great diagnostic value in determining the retroperitoneal character of masses.

Dr. Carlos Heuser, Buenos Ayres. With the dental anaesthetic apparatus of Clark, intended for oxygen gas and ether, I use a mixture in the proportion of 35% gas to 15% sulphuric ether by drops which are mixed with the gas and 55% oxygen, giving 1500 to 3000 c.c. of this mixture with my special needle. The advantages are as follows:

1. The patient can be examined standing. Deep breathing does not hurt him..
2. The mixture is absorbed rapidly.
3. The patient is not left with any pains.
4. The method can be used in the consulting room.
5. There have been observed no abnormal symptoms.
6. With the manometer attached to the instrument, it is possible to measure the quantity of gas injected, to know the pressure, and whether or not the gas mixture has penetrated into the abdominal cavity.

The needle is of platinum with a special mandrin and an escape key similar to the ordinary trocars. The purpose of the mandrin is to prevent the needle from bending when the puncture is made. The cannula with the escape key gives escape to the air after the roentgenogram has been finished. I leave the cannula in the abdomen during the making of the plates. I consider this method a great advantage and a great relief for the patient.

Dr. W. C. Alvarez. Generally we put in gas with the patient on his back. It seems to me that this gas might be trapped on one side or the other, depending on whether he rolls over to the right or to the left. Much depends, also, on whether the body is quite even on the table.

I think this type of case which Dr. Sante has just described is the type in which you must use oxygen or air or something else that will stay. It is well not to use too much; one to two litres I find is generally sufficient. Don't do this work for idle curiosity, and don't do it if there are any signs of inflammation.

Dr. A. F. Tyler. I would like to ask Dr. Alvarez if he has had any trouble in introducing carbon dioxide with the patient going into shock.

Dr. Alvarez. I have had nothing like that.[1] Most of the patients have had very little trouble. Don't let them sit up or stand up until they have had the gas in them for some time.

Dr. William H. Stewart. Dr. Rubin's work on testing the patency of the fallopian tubes by means of injecting oxygen into the uterine cavity is entirely foreign to pneumoperitoneal *x*-ray diagnosis, so much so that the speaker does not feel competent to discuss the communication although he can readily appreciate the value of such a procedure.

[1]Note: Since this meeting I have seen one case with most alarming cyanosis and stoppage of the heart, showing again that this technique should not be used thoughtlessly or needlessly.

Dr. Van Zwaluwenberg's presentation has been most enlightening, particularly so as the practical value of pneumoperitoneum in pelvic cases has long been a question in the speaker's mind. Many gynecologists will not accept the method as a routine procedure, saying that they are able, except in some very obscure cases, to make their diagnosis without pneumoperitoneum. There is every indication, however, that the method will be so simplified that it can be used in all cases where a diagnosis cannot be made by the ordinary methods.

Dr. Sante's remarks with reference to the question of gas collecting on one side of the peritoneal cavity, is debatable. Personally the speaker believes it is purely a coincidence, for unless the abdominal cavity is inflated to a considerable extent the gas is apt to collect in any one place. One of the difficulties to contend with in this work is to obtain a uniform distribution of the gas. Intestines which are distended with gas or feces will prevent this uniform distribution, and frequently form pockets in the peritoneal cavities where the inflated gas will accumulate.

Dr. Alvarez' communication is most important and great credit should be given to him for the suggestion of the use of carbon dioxide instead of oxygen. The inflation technique which we are employing at the present time is somewhat similar to that reported last year. If a complete fluoroscopic as well as roentgenological examination is required, oxygen is the gas of selection. Should the investigations be of a single organ, such as the gallbladder, carbon dioxide is used. This gas is absorbed very rapidly, usually disappearing in about half an hour. A mixture of 2 parts of carbon dioxide to 1 of oxygen is very satisfactory where the investigations will consume about an hour.

[The speaker showed lantern slides of a series of cases in which pneumoperitoneum had proved of great value in securing a diagnosis.]

THE COLLATERAL TREATMENT OF MALIGNANT PATIENTS UNDERGOING RADIOTHERAPY*

By E. H. SKINNER, M.D.

KANSAS CITY, MISSOURI

PROBLEMS are constantly arising in the management of malignant patients who are undergoing radiotherapy. The comfort of our patients and their symptomatic care is quite another thing from the actual application of radiant energy.

There are two aspects to radiotherapy and the malignant patient. The one presupposes that the application of the radiant energy is the one essential. The patient and his disease are overlooked in an ambition to secure the proper dosage and consequent shrinkage of the tumor mass.

The viewpoint that I wish to present may be summed up in the aphorism: Beyond the cancer is the cancer patient.

If we had a panacea for malignancy in radiant energy there might be some excuse for overlooking the patient and simply treating the malignancy. Unfortunately this is not so. Therefore we shall probably achieve a more reasonable success if we observe ways and means to promote the comfort and symptomatic relief of our patients. The more one is engaged in the handling of this class of patients, the more does one realize that our therapy is far from being a specific in spite of the remarkable changes that the tissues obtain from radiant energy.

The chief difficulties with our malignant cases are poor morale, deficient appetite, irradiation sickness, distressing local symptoms and the subtle changes in the blood and internal secretions. Upon the latter, much may be conjectured, little is known; but it may not be amiss to venture certain observations, relate certain animal experiments and their possible application in ra-

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

diologic practice. The former group of systemic difficulties is met in almost every case of desperate malignancy. The local symptoms necessarily vary with the type of involvement.

The subject easily divides itself into the following headings:

1. The mental attitude of the patient.
2. The general state of health of the patient.
3. The dietetic care of the patient.
4. The adjuvant therapy of local and general symptoms.
5. Amelioration of symptoms by variation of dosage.

The Mental Attitude of the Patient.—Patients come to the radiologist with great hopes of relief and possible cure. Every effort should be expended to maintain this attitude even to the extremity of prevarication, because it is noticeable that the patient loses rapidly as soon as he loses hope. This hopeful attitude is an enormous factor. The physician should, however, never fool himself or the family. There should be a perfect understanding between the radiologist and some responsible member of the family.

On the other hand if the patient comes to the radiologist reluctantly and without hope it behooves one to make every effort to raise the morale of the patient by encouraging the fighting spirit and hopeful attitude. This is hardly fair in the absolutely hopeless case. The judgment and experience of the radiologist is far more important than the potency of his irradiation in this situation. Again would I invoke the words of Shakespeare:

> . . . to thine own self be true,
> And it must follow, as night the day,
> Thou canst not then be false to any man.
>
> *Hamlet,* Act I, Sc. 3.

This buoyancy of hope is a greater factor than tonics in maintaining the general condition and the appetite of the patient. The cheerful attention of the physician and those in contact with the patient and the minimizing of the symptoms to the patient are worthy ideas.

The General State of Health of the Patient.—The general state of health of the patient which necessarily includes the diet should be constantly in mind, for in our efforts to eradicate malignant tissue we may be taking advantage of the reparative powers of the patient or developing gastric symptoms which will negative our local results. Every radiologist must be cognizant of the violent gastric symptoms which are coincident with radiant therapy, especially of the abdomen. There are reliable reports of metastases supposedly caused by vigorous treatment of the apparently localized malignancy. There is ample evidence from animal experimentation that radiation has the capacity of destroying the very cell factors in the blood which are at the same time the most potent agency in the actual destruction of the malignant cell. We refer to the lymphocytes of the blood. While heavy dosage will destroy the lymphocytes, small repeated doses will stimulate their development. The thought therefore arises—is it always best to attempt to overwhelm a malignancy with deep penetrating dosage, or should an attempt be made to fortify the patient by stimulating his cellular resistance to malignancy? Furthermore, may we not be hastening or actually producing metastasis by vigorous primary radiation? The idea of immunizing the patient by gradually increasing dosage may be worth consideration.

In spite of the dissensions of opinion regarding the so-called acidity or alkalinity of cancer patients, it is our humble experience that it is more comfortable to the patient to promote the alkalinity of the excretions and at the same time quiet the gastric symptoms. The milk of magnesia is a most valuable remedy, as it tempers the stormy stomach and favors colonic regularity. The drinking of waters which carry a high soda content is more agreeable than frequent dosage with soda bicarbonate. The latter is valuable to promote a rapid alkalinity when the patient is first seen and for acute attacks of gastric discomfort, but the milk of magnesia and the waters are better for long periods of time.

The Dietetic Care of the Patient.—When one seeks the literature for information upon

the dietetics of malignancy one finds contradictory ideas. For many years the teachings of Bulkley have held us to the idea that alkalinity should be the goal. The experience of radiologists with deep irradiation sickness and the general relief of symptoms by soda bicarbonate seems to make us disciples of Bulkley. Now comes one worthy Joslin to the opposite opinion with an interesting array of argument:

"There never was in the world two opinions alike, no more than two hairs or two grains; the universal quality is diversity." *Montaigne.*

"Inconsistencies of opinion, arising from changes of circumstances are often justifiable." *Daniel Webster,* Vol. v, p. 187.

"Thus times do shift—each thing his turn does hold;
New things succeed, as former things grow old."—*Herrick.*

Experience and custom seem to demand that the general diet should tend toward alkalinity. Milk and the vegetables and cooked fruits and cereals are easily the basis of the daily dietary. Bulkley has outlined very specifically the intimate details of rotating variations in the daily meals. Torbett has furnished an alliteration that sticks: "Prunes, plums, peanuts; Canteloupe, cabbage, cranberries; these are foods which leave acid radicals in the blood." It is well to remember that spinach is richer in iron than any other vegetable and that the baked potato eaten with the skin furnishes a great deal of lime. Whole-wheat bread and popcorn are happy thoughts.

Dietetic experiments upon rat tumors, quoting Corson-White, reveal that a diet of vegetable protein, fat, and carbohydrates retard the growth of tumors, while the general condition of the animal seemed normal. On the contrary, high cholestral feedings seem to increase tumor growth. Hunt Reid finds that it may be well to consider diets that influence the ductless glands; oats and potassium iodide stimulate the thyroid, while eggs and milk inhibit the thyroid.

As an element which may be of increasing interest we would suggest blood transfusion for the patient who has a decided alteration in the blood picture due possibly to irradiation. This procedure may be considered where there is a low lymphocyte count or a pernicious anemia. In the former it would probably be wiser to withdraw a certain amount of blood and then donate a similar amount from a properly typed doner. In the latter case—pernicious anemia—a properly typed blood could be given without any withdrawal. It is probably best to hypothocate that the low lymphocyte count is due to irradiation and there is no decrease in the red blood cells, while in the pernicious anemia the condition is a sequela of the malignancy.

The Adjuvant Therapy of Local and General Symptoms.—Therapeutic suggestions may be grouped as general or local.

General measures are Blaud's pills, bitter tonics, potassium iodide, arsenic and strychnia, arsenical injections (salvarsen), protonuclein and glandular extracts. There is no reason why the patient should be denied the possible advantages of remedial measures of historical value simply because they are now undergoing a treatment by radiation and hope.

The use of arsenical injections and glandular extracts to enhance the value of radiation is worth consideration. We would also reiterate the values of the milk of magnesia and alkaline waters as general therapeutic measures in every case.

The local symptoms vary. With uterine malignancies we have the bladder and rectal symptoms (eminent radiologists to the contrary). With sigmoid and visceral malignancy there are few local symptoms. With mouth and throat cases, there are the distressing symptoms of ptyalism, pain, and ulceration and bleeding.

Brief local measures are suggested as follows:—Pelvic malignancy: Peroxide cleansing. Mild astringent tampons. Chloretone and icthyol tamponage. Acetone packing.

Dakinize with extreme care for the viable tissues for twenty-four hours at three days' interval.

Breast Malignancy: Potassium permanganate for ulcerations. Salt pork poultices. Screening with parafine mesh. Balsam peru. Peroxide cleansing. Aristol dressing.

Mouth Malignancy: Potassium iodide to promote mucous membrane activity and atropine in alcoholic to physiologic equilibrium for ptyalism. Potassium chlorate for mouth wash. Pack ulcerations with soda bicarbonate. Silver nitrate applications.

Pain: Start with aspirin. Add phenacetine. Turn to papine. Then codeine. Terminal refuge is morphine.

The cancer patient is entitled to relief from pain, as there is nothing to be gained by fighting the pain or bearing the pain. It is bad enough to endure an incurable malignancy, so why add the burden of pain and discomfort. Irradiation surely reduces and sometimes eliminates the pain and it surely affords an easy exitus for the desperate malignancies even if it does no more.

There is no doubt but that irradiation by *x*-ray and radium is the greatest boon that the malignant patient has had during all the ages, and it has surely come to stay as a possible cure in many conditions; at least a prolongation of life is assured, and always comfort to the patient when not a cure.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M.D., *Editor* - Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

SIXTH ANNUAL MEETING THE AMERICAN RADIUM SOCIETY

BOSTON, JUNE 6 AND 7, 1921. HEADQUARTERS, HOTEL BRUNSWICK

WASHINGTON MEETING

PRELIMINARY ANNOUNCEMENTS

Plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. René Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it necessary to attend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

A. C. Christie.

The Twenty-second Annual Meeting of The American Roentgen Ray Society will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of The American Roentgen Ray Society. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person,	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On

these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

THE CALDWELL LECTURE FOR 1921

The American Roentgen Ray Society is very fortunate in having secured Dr. René Ledoux-Lebard of Paris to give the Caldwell Lecture at the annual meeting this year. The distinguished standing of Dr. Ledoux-Lebard as a roentgenologist and his charming personality make it certain that the high standard already established for this lecture will be maintained.

Annual Meeting Western Section

The officers of the Western Section of The American Roentgen Ray Society are making plans for their second annual meeting. They have selected Portland, Oregon, as the place of meeting, and the time has been set for May 27th and 28th. This time will permit of a continuous trip for the western men who desire also to attend the A. M. A. meeting in Boston.

The Pacific Coast Roentgen Ray Society will meet at the same time and place, the two organizations being the guests of the Portland Roentgen Club, a very active organization of specialists.

The Secretary of the Western Section would welcome a visitor or two from the East with papers or demonstrations, and can assure them of a very enjoyable meeting. Address Dr. Warner Watkins, Box 1328, Phoenix, Arizona.

REPORT OF MIDWINTER MEETING CENTRAL SECTION

The Second Annual Midwinter Meeting of the Central Section of The American Roentgen Ray Society was held in St. Louis, at the Hotel Statler, on February 21 and 22, with about eighty-five in attendance. The program for the two days is as follows:

Monday Morning, February 21, 1921

9:30 Opening with a Business Meeting.
Appointment of Nominating Committee.
Dr. J. M. Martin, Dallas, Tex. *X-ray Treatment of Acne Vulgaris.*
Dr. D. Y. Keith, Louisville, Ky. *Sarcoma Therapy.*
Dr. Charles C. Grandy, Fort Wayne, Ind. *Fracture of the Pelvis.*
Dr. L. T. LeWald, New York City. *Report of a Case of Hernia of the Diaphragm on the Right Side* (Confirmed by operation).
Dr. D. C. Upson, Battle Creek, Mich. *Situs Inversus.*
Dr. H. J. Ullmann, Chicago, Ill. *The Use of the Sphere Gap for Measuring Voltage in Roentgenotherapy.*

1:00 Lunch.

2:00 Election.
By Invitation:
Dr. George Dock, Professor Internal Medicine, Washington University Medical School. *X-Ray from the Viewpoint of an Internist.*
Dr. J. M. Cork. *The X-Ray Spectrum and its Relations.*
Mr. Frank Rieber, San Francisco, Cal. *The Importance of Accurate Standardization of Tube Potential in Therapy.*
Dr. Charles Hugh Neilson, Professor Internal Medicine, St. Louis Medical School. *The Internist's Viewpoint of the Roentgenologist.*

Dr. P. M. Hickey, Detroit, Mich. *Roentgen Diagnosis of the Pancreatic Cysts.*

Dr. A. W. Crane, Kalamazoo, Mich. *Reconsideration of the Barium Meal.*

Dr. E. H. Skinner, Kansas City, Mo. *Congenital Atresia of the Esophagus.*

Executive Session for the Election of Officers.

Monday Evening, February 21, 1921

7:00 Banquet.
Lantern Slide Exhibit.

Tuesday Morning, February 22, 1921

9:30 Clinical Visit to Washington University Medical School and Barnes Hospital.

Tentative program had been arranged as follows:

(a) Dr. E. L. Opie, Professor of Pathology, Washington University Medical School. *Tuberculosis* (Demonstrations of specimens, lantern slides, etc.).

(b) Dr. R. Walter Mills, Dr. Sherwood Moore. *Demonstrations in the X-Ray Department.*

12:00 Central Dry Plate Company Visit.
Buffet Luncheon (Courtesy Central Dry Plate Company).

Practical Demonstration of the Various Stages in Dry Plate Manufacture.

Visits to Local Laboratories.

The morning and afternoon sessions of the first day were occupied with reading and discussing the very interesting and scientific papers by the members and invited guests. These papers ranged in subjects over the viewpoints of the physicist, internist, diagnostician, and therapist.

Dr. Dock and Dr. Neilson, Professors of Internal Medicine in the Washington University Medical School and in the St. Louis University Medical School, respectively, brought out an important point which could be taken as a criticism in part of the roentgenologist and in part of the consultant: viz., that while there are many cases in which diagnoses can be given on one examination, there are still a large number that should have repeated examinations before the positive findings are rendered. They cited as instances, cases sent long distances because of chest findings, and major operations undertaken because of abdominal findings.

The banquet was well attended, and the pleasing music provided by the St. Louis Committee was enjoyed by all. The toastmaster, Dr. Skinner, won the hearts and applause of all when he announced that owing to the lateness of the hour and the previous entertainment, speeches would be dispensed with.

The lantern slide exhibit, following the banquet, lived up to its usual reputation, and was the most fascinating part of the meeting. Dr. R. Walter Mills presented a series of interesting stomach slides with tables showing his classification of the different types of the human form, each type having its characteristic stomach picture. Many other members exhibited a variety of slides, and much good-natured rivalry was brought out in trying to show some condition or anomaly not previously seen by one of our visitors.

The midnight sessions were held as usual in the various rooms.

On the morning of the second day the members were driven to the wonderful University Medical School and Barnes Hospital, where Dr. Opie, Professor of Pathology, lectured on tuberculosis, using lantern slides for demonstration.

A splendid buffet luncheon was served to the Society at the Central Dry Plate Company, after which the plant was inspected and the methods of plate-making were seen. It was necessary to traverse the dimly lighted parts of the factory in chain-gang fashion, as the ordinary dark-room is lighter and more easily negotiated.

A vote of thanks was given to the St. Louis Committee for their splendid arrangements and entertainment.

Dr. J. G. Van Zwaluwenberg presided.

Dr. A. F. Tyler, the Secretary, was unable to be present; Dr. William M. Doughty was appointed Temporary Secretary.

The Local Committee consisted of Dr. Edwin C. Ernst, Chairman, and Drs. E. H. Kessler, Fred B. Hall, M. B. Titterington, and L. R. Sante.

The following officers were elected for the next year:

President
Dr. William M. Doughty, Cincinnati, Ohio
First Vice-President
Dr. D. Y. Keith, Louisville, Kentucky
Second Vice-President
Dr. E. S. Blaine, Chicago, Illinois
Secretary-Treasurer
Dr. A. F. Tyler, Omaha, Nebraska

The next meeting will be held in Chicago, the date to be decided later.

ADDENDUM

Dr. Alfred S. Doyle makes the following addition to his article on page 73 of the February issue:

In the American Atlas of Stereoroentgenology, Vol. II, Dr. H. M. Imboden of New York reports a case injured in October, 1916, which was operated upon October 11th, for depressed fracture. Roentgen examination made November 8th shows an area of diminished density in the upper portion of the cranium which he believed at that time was air in the cranial cavity. On December 7th of the same year another roentgen examination was made and shows the air completely displaced by brain tissue; this patient is reported as having made a complete recovery without operation for the air.

DOSAGE MEASUREMENT

A Criticism

By J. S. SHEARER
CORNELL UNIVERSITY, ITHACA, N. Y.

Some years ago the writer of this article published a paper on the photographic effect of x-rays when variations of current and voltage were made and *no* filtering material except the walls of the tube and the usual paper envelopes were between the target and the sensitive emulsion. The results showed that for a *given* wave form the time required to secure identical blackening of spots on the same plate could be quite accurately computed by assuming that:

1. The time was inversely proportional to the current when voltage and distance were unchanged.

2. The time was inversely proportional to the *square* of the *effective voltage* when current and distance remained fixed.

3. The time was directly proportional to the square of the target plate distance for current and voltage unchanged.

Thus for unfiltered rays the photographic effect was indicated by the relation

$$\frac{\text{current} \times (\text{voltage})^2 \times \text{time}}{(\text{Target — plate distance})^2}$$

Also the reasonably accurate reproduction of results with different machines, as indicated by photographic action when reasonable care was taken, suggested the use of these measurements *in the place of Kienböck strips or pastilles.* This was advocated because observation of the work of many students showed there was better agreement in results than when the prevailing methods were employed. Measurements by ionization methods have indicated the above formulation to be substantially correct within the range of voltages in common use and where wave forms do not vary too much. Also, since in this same range "spark gaps" are nearly proportional to voltages, gap measurements may be substituted for voltage. The use of this method has become fairly general in this country, and we now see statements of current, gap, filter, distance and time as a rule instead of so many H or X units.

The general principles of physical measurements are sometimes rather complex and are often not well understood. This is always true when methods are developed and units adopted before facts can be fully investigated, also methods are frequently applied in ranges outside their proper limitations.

As an example, assume that we wish to use a photographic method to measure light. Let portions of a plate receive exposures for 1, 2, 3, 4, etc., units of time to radiation from a constant source. No one would question that here exposures would be in proportion to the times. If we lay off along a horizontal axis a series of equal steps as 0-1, 1-2, 2-3, etc. (Fig. 1), we may erect perpendiculars

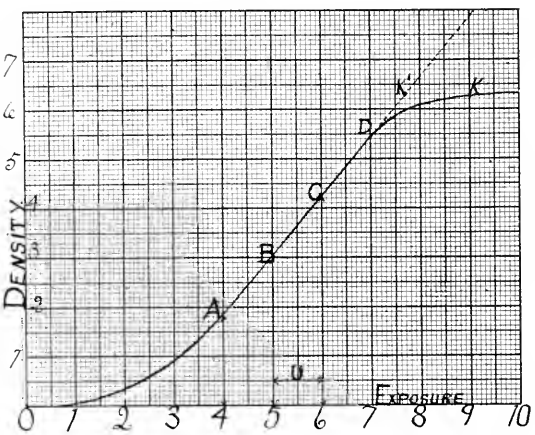

FIG. 1. VERTICAL LINES SHOW DENSITIES CORRESPONDING TO EXPOSURES SHOWN AT BASE. Thus A4 is 1.9 in length, B5 is 3 units, or 4 arbitrary exposure units gave 1.9 units of density.

at these points whose lengths correspond to the measured density of the negative where these exposures acted. Suppose one made measurements between A and D, and observed that here density increased very nearly in proportion to exposure. A unit for exposures might be chosen as U, and we say that A received 4 units, B, 5 units, C, 6 units. Any other area having a density *equal* to that at A would also be said to have received 4 radiation units. If now we attempt to use the density of the negative as a measure of exposure below A, or above D, we have trouble, since a small exposure may cause *no* measurable density. Neither can we infer from the density K what exposure the corresponding spot received. For had the relation between exposure and the density produced not changed, then this particular density would have been attained by a shorter exposure. Thus no determination of exposures below or above certain limits are possible: below there is little or no density, while above the density changes but slightly even with great increase in exposure.

The same applies to a pastille, too little exposure will not cause a perceptible color change, and after a certain yellow brown tint is reached no further change in tint is observed. Also if an exposure *exceeding* certain limits is made there is no way of determining *how much excess radiation has been received.* Pastilles were introduced when induction coils and gas tubes were in general use and there were wide differences in outfits. The fact that their maximum change in tint was so nearly attained by exposure to a quantity of radiation that could safely be delivered to the skin made them exceedingly valuable for skin therapy at that time. But in the use of fractional doses, heavy filtered doses, and when we consider the difficulties of keeping and reading pastilles we recognize the need of some other measure.

We sometimes say that one quantity "runs parallel" with another, meaning they increase or decrease together in a fixed ratio. Thus on the straight line portion of Figure 1, exposure and density "run parallel" over a considerable range, but not over all ranges. The biological action of many, perhaps of all stimuli, varies with the dose according to a law similar to that "of decreasing returns" in economics, or by an approximately logarithmic or exponential law. Thus Figure 2

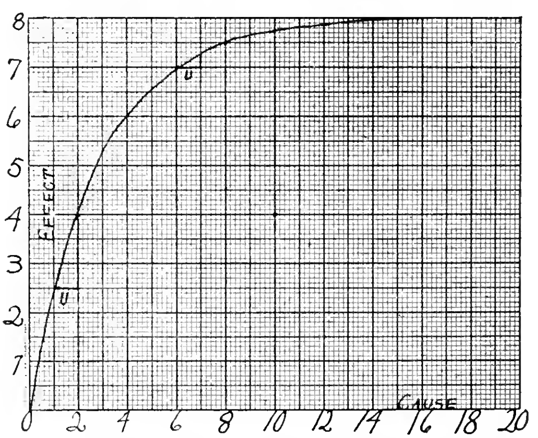

FIG. 2. A COMMON RELATION OBSERVED BETWEEN CAUSE AND EFFECT. The second unit of cause gave 1½ effect units. The 7th only .3 of a unit.

shows such a curve. To assert that each unit of the acting agent produces the same effect would be absurd, as successively applied units of causation give entirely different additions to the effect. And yet that is just what is so often done in the use of "pastilles," Kienböck's, etc., in therapy.

The therapist *need* not be concerned with such units at all. What he needs to know is *how to operate his tube to secure* the most favorable curative result with the least risk; viz., what current, voltage distance, filter, time, areas of entry, and intervals between treatments are most likely to secure a good therapeutic effect with a minimum risk of skin lesion. Also under what conditions may this dose be exceeded and by how much, when the net result may be favorable to the patient, even though temporary injury to the skin ensues.

Such a specification of dosage may seem not to involve any consideration of the laws of physics. But *this is not the case* and especially so when one considers questions of deep therapy, of filters, of proposed variations in apparatus and countless other phases of the development of therapy in which we are bound to be guided by our concepts of physics. The well established laws of radiation need no defence, neither do their careful consideration in the matters at hand require any apology.

It seems to the writer quite unfortunate at this time, when we are shortly to be able to clear up many of the disputed points in therapy, to have several articles in this and other journals giving quite erroneous interpretations of observations. The first article by Remer and Witherbee in June, 1917, questioned the voltage law as measured by pastilles. There was no reason to assume that photographic densities and color changes would run parallel to each other or either of them to skin effects over any considerable range. And no claim had been made that such was the case.

In this same article the inverse square law was questioned when filters were used. While the writer dislikes to appear controversial, references to his work have been made in several of these articles, and he has recently received letters from many sources asking if the published results are in accord with his experiments. This seems to make a public answer unavoidable, especially as the writers of some of these letters say they had unfortunate results when believing they followed Witherbee and Remer's formulation.

As in many other cases many of the *observations* of these authors are of value even though their *explanations* may be wrong, but explanations based on incorrect ideas almost invariably lead, sooner or later, to absurd or dangerous procedures. In some cases they result in the development of improper or useless appliances, in others in serious injury to patients, and they always tend to bring the work into disrepute.

When writers challenge the validity of well established physical laws they must expect a critical scrutiny of their contentions. So in the present case we may consider various statements of these authors as to their concordance and probability. In all of Witherbee and Remer's work full reliance is placed on their pastille readings or on color changes on the skin. As regards the latter one might secure a fairly pronounced erythema that would hardly be deepened in color by a considerable increase of exposure. There may also be quite a difference in biological effects at greater depths for the same apparent erythema. As regards the comparison of erythemas and coloration of the skin it would be well to remember that preconceived notions may unconsciously greatly influence readings in color matching. It is certainly questionable whether an ordinary photograph of the patient's skin is a reliable indication of the effect of radiation.

Taking now the article by these authors in the *N. Y. Medical Journal*, June 26, 1920. We may note reference to the work of 1917, where it was first asserted that the inverse square law was in error for filtered rays. All factors except distance remaining the same it is stated that at half distance one gets only twice instead of four times the dose. Or if

one gets, say, 4 units at 10 inches one would get 2 at 20 inches instead of only 1.

Such a result is contradictory to all physical experience with radiant sources as small as we have in the *x*-ray tube where the variation of distance from various points of the source to an external point is too slight to consider. The claim is also self-contradictory since any given filter absorbs a definite *fraction* of the radiation it receives quite independent of the intensity. Placed close to the source more is received and more absorbed, further away less is received and correspondingly less is absorbed, but always the same fraction of that received.

Now the authors admit the inverse square law is all right for unfiltered rays.

Suppose a filter, F, (Fig. 3), is placed at 5 inches from T and the radiation is received on an areas S just beyond F. Let F receive 8

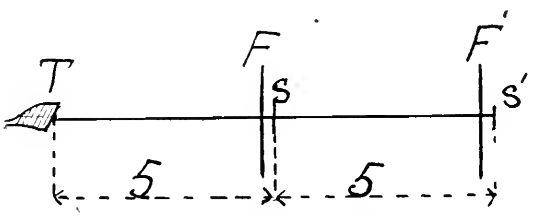

Fig. 3. F just in front of S receives 8 units of radiation, it filters out ½ or transmits 4 units. This gives only one unit on an area S' equal to S but twice as far away. Remer and Witherbee say it gives 2 units. Transfer F to F', they admit that if not filtered the intensity at F' (no filter at F) would be only 2 units and it removes 50% and we get only 1 unit on S'.

arbitrary units of radiation per sq. cm. and be of such a thickness as to absorb 50 per cent of this amount, then a sq. cm. perpendicular to the rays just beyond F would receive 4 units. According to Witherbee and Remer a sq. cm. of surface S, at 10 inches would receive two units instead of only one as predicted by the inverse square law. Now move the filter twice as far away to F; at 10 inches it is admitted that the filter would *receive* only one fourth of what it did at 5 inches, or only 2 units.

Receiving only 2 units and absorbing 50 per cent of what it received, it would transmit only *one unit*. So it would follow if the physical law is not obeyed it would make a great difference where we placed the filter, while in fact it makes no difference.

It is interesting to observe that their claim as to the effect of distance is exactly comparable to their observation on change of voltage, i.e., if the V^2 law is true we would have four times as much rediation for a doubled voltage. They say only twice as much. Halving the distance gives four times as much radiation on the same area, but these authors say they read only twice as much. Does it not seem strange they should get this *exact* discrepancy in two different cases and, granting as good readings as possible, would not one be justified in doubting the method?

Next in this article we read that dosage is not in proportion to time. Using 3 mm. of al. and all remaining conditions the same:

2 min. gives 1 H
2 × 2 min. gives 1½ H
3 × 2 min. gives 2 H

Summarizing, if at a voltage V, distance D, and time T, we get a dose H:

	Physical laws predict:	Witherbee & Remer assert:
At ½D	4H	2H
At 2V	4H	2H
At 3T	3H	2H

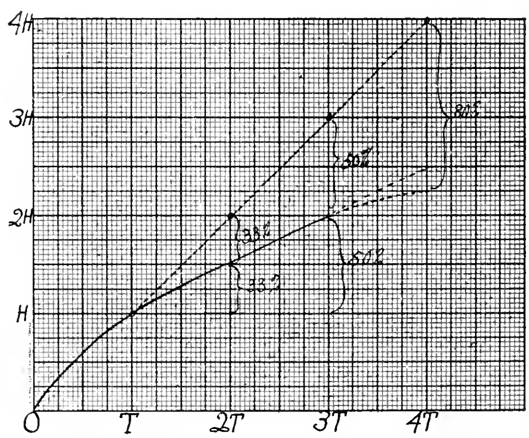

Fig. 4. Increase in Dose Indication with Equal Increments of Time. Dotted straight line shows how an indicator ought to behave. Full line shows Remer and Witherbee readings. Exterpolated beyond by dotted lines. Uncertain just how it would read at 4T.

This failure of the pastilles to read in proportion to *time* according to the observations reported is significant. In Figure 4 the straight line shows the increase of dose with increase of time, all other factors unchanged.

T = time for 1 skin unit. But their reading at 2T must be increased by one third of itself to come to 2H, the reading at 3T must be increased by 50 per cent of itself to give 3H, and extending the curve, in the absence of readings, to 4T, indicates that the *reading* at 4T would have to be increased about 80 per cent to satisfy the law of constant increase with time. Hence if under one set of circumstances the pastille is so much too low that one must add 80 per cent to 2H to get a rational measure, just why not add, say, 100 per cent to the 2H reading in the voltage and in the distance experiments?

The law of *uniform increase of dose with time* for all other conditions constant has always been used to determine the fractional scales for both the Kienböck and pastille methods. After a reading of 2H was attained we were told to *double* the *time* for 4H. Thus the scales used by these authors were fixed by using the laws whose validity they deny.

There should be a careful distinction between applied dose and the effect produced by the application. Thus if 5H is the *dose* received by a pastille it shows a marked change in color, if an additionad *dose* of 5H is then applied but little further color change is shown. The dose is a physical entity, its effect is dependent on the variable state of the receiving substance. Also if a tendency to recover is present we have another factor involved. Thus with very weak radiation in moist air and diffuse light one may have the rate of recovery of a pastille just balance the action of the radiation, yet one would hardly claim no dose.

In this same article we read as follows:

"Recently the pastille readings were taken using ¼, ½, 1, 2, 3, 4, 5, 6, and 7 mm. of aluminum, respectively. Throughout these experiments, instead of the half distance pastille registering *twice* the amount of that at full distance we find that when the half distance pastille reaches *one* and *a half* skin units the full distance pastille reads *one skin* unit and when the half distance pastille reaches two skin units the full distance reads one and a quarter. The only exception to this is when 5, 6 and 7 mm. of aluminum are used. These register half the dose of full distance and formula. This agrees with the biological results."

It is rather strange that *only after 5 mm. are used do we get agreement with biological results.*

In their previous work they declared a ratio of 1 to 2 for 3 mm. of aluminum at full and half distance. The physical law asserts the ratio is always 1 to 4.

Remer and Witherbee read 1 to 1.5 at first, then 1¼ to 2, or 1 to 1.6 up to 4 mm. of aluminum, then at once 1 to 2. So we see that the pastilles are not consistent with themselves as the *ratio* of readings is variable when two are treated alike for comparison.

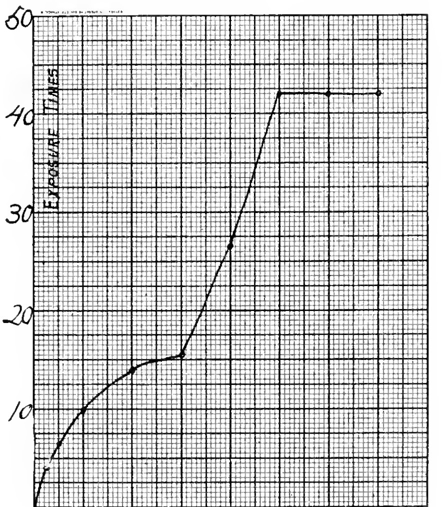

Fig. 5. Exposure Times for 1H, Current, Distance and Gap Constant but Using Different Thicknesses of Aluminum. Such an irregular line is *highly* improbable.

One way in which we may see whether results are fairly reasonable or not is to plot curves between two related quantities. Plotting from the data given, time for one skin

unit at constant gap, current and distance against thickness of aluminum used as a filter we have Figure 5. Such results are quite impossible unless *all* experiments done heretofore are wrong. Why such a break at 3 mm. and such a jump between 4 and 5? And surely no one knowing anything of the effect of thickness can believe that 7 mm. and upwards would transmit the same amount of radiation as 5 mm.

Again we read:

"The principle involved in this experiment apparently changes the classical law of light, namely, the amount of light varies from the source according to the inverse square of the distance. Filtered *x*-ray produces double the amount of half distance instead of four times.

"We understand that these results in no way conform to any existing law of physics. We have been unable thus far to explain the cause of the above phenomena and simply wish to report our findings."

The authors further remark: "We do not see the necessity of using more than five mm. of aluminum as a maximum without the addition of a piece of glass, leather, or wool." Why add glass, leather or wool? Because of some property not recognizable by physical experiment? Or because some have used these as filters? At the end of the reprint we are told their "results explain the practicability of filtered ray for producing the maximum effect on the parts beneath the skin when compared with unfiltered dosage." A fact fully explained without any need of the denial of the laws of radiation. The whole result of these arguments is, if anything, to discredit entirely such methods of measurement.

In the *Medical Record*, July 31, 1920, we have another article entitled "The Cause of X-Ray Burns."

There appears in this article so much that is fallacious that it constitutes a serious menace to rational therapy. Omitting the figures that purport to show equality of dosage by ordinary photography of the skin the main portions of the article may be quoted. The paragraphs are numbered solely for easy reference.

1. "During the early days of roentgenology, when the gas *x*-ray tube was all there was, we were especially warned against the use of any factors with very low voltages, for the reason that low voltages produce an immense number of rays of low penetration which are absorbed by the skin and hence more liable to cause an *x*-ray burn than the high voltages whose rays are of high penetration and not absorbed by the skin.

2. "The above theory has been handed down from year to year and it is only within the last few years that the fallacy of it has been realized.

3. "Soon after the announcement of Saboraud and Noire method of treatment of ringworm of the scalp, many attempted to carry out the procedure with an *x*-ray coil instead of a static machine as used by the originators. This resulted in overdosage and permanent baldness in many of the cases. The reason for this was the failure of the operator of the coil to maintain a constant high voltage for any length of time as compared with the tube maintained by the static machine.

4. "This drop in voltage in the gas tube no doubt increases the number of low penetrating rays, and it was naturally concluded from the theory of absorption that they were the cause of permanent alopecia or *x*-ray burn. In order to test out this theory, the following experiment was made with a Coolidge Tube and reported in the June issue of 1917 of the *American Journal of Roentgenology*.

5. "Four areas of a patient's back were treated with the following factors for each area:

MA Sp. G. T

No. 1. $\frac{3\times3\times5}{8D\times8D}$ = 1¼ skin units = 5H;

No. 2. $\frac{3\times6\times2\frac{1}{2}}{8\times8}$ = 1¼ skin units = 5H;

No. 3. $\frac{3\times4\frac{1}{2}\times3\frac{1}{3}}{8\times8}$ = 1¼ skin units = 5H;

No. 4. $\frac{3\times9\times1\frac{2}{3}}{8\times8}$ = 1¼ skin units = 5H.

6. "The photograph of the patient taken

ten days after treatment demonstrates that all areas coincide, yet in two of them, namely No. 2 and No. 4, the spark gap was doubled and one-half the time taken for exposure that was given in No. 1 and No. 3, respectively. It therefore follows that if the spark gap is doubled and the time reduced one-half, the same degree of erythema will be produced, other factors remaining constant.

7. "From the standpoint of quality of x-ray in the above experiment, the formula with 6-in. and 9-in. spark gaps (No. 2 and No. 4) should give a very large percentage of penetrating rays as compared with the 3-in. and 4½-in. (No. 1 and No. 3), and hence one would expect that these penetrating rays derived from the higher spark gaps, 6 and 9 (No. 2 and 4) would pass through the skin and take much longer to produce the same degree of erythema as that followed by the use of 3 and 4½-in. formulae (No. 1 and No. 3). Exactly the reverse proves true. For it took just one-half the time for the same biological effect in the doubled spark gaps (No. 2 and No. 4) as it did in the 3 and 4½-in. (No. 1 and No. 3) formulae.

8. "It is, therefore, apparent that the quality of the ray and the absorption of those of long wave length have little to do with the biological effects in the skin. On the other hand, it seems that the factor which determines this effect is solely the quantity of x-ray reaching the skin, for it is obvious that a high spark gap produces more rays that reach the skin than the same dose with a low spark gap.

9. "Recently we have tried out the following factors on the skin of a patient's back:

$$\frac{\begin{array}{c}\text{MA Sp. G. T}\\ 5\times 9\times 9/1.6\text{ min.}\end{array}}{6\times 6\text{ D}} =$$
$$33\tfrac{3}{4}\text{ sec.} = 1\tfrac{1}{4}\text{ skin unit} = 5\text{H.}$$

10. "This is an erythema dose without a filter. The filtered erythema dose using 3 mm. of aluminum is as follows:

$$\frac{\begin{array}{c}\text{MA Sp. G. T}\\ 5\times 9\times 7.7\text{ min.}\end{array}}{6\text{ D}} =$$
$$2\tfrac{1}{2}\text{ skin units} = 10\text{H.}$$

11. In the photograph both areas of erythema are identical. No. 1 was produced by the unfiltered erythema dose; No. 2 by the filtered erythema dose. Biologically, to all appearances, the erythema produced in 33¾ seconds by the unfiltered ray is the same as that produced in 7 minutes and 42 seconds by the filtered.

12. "If the voltage determines the quality of the ray, then in this experiment the voltage is the same in both instances; the only difference is the interposition of 3 mm. of aluminum and about ten times longer exposure for the filtered dose as the unfiltered. Here again the quantity of x-ray reaching the skin is materially lessened by the aluminum, thus making the enormous difference in the time of exposure.

13. "This dose with 3 mm. of aluminum takes a little over ten times as long to produce an erythema as it does without aluminum. In speaking of this dose some writers would say that they gave ten erythema doses. This statement without qualification is misleading. In reality the effects, so far as the skin reaction is concerned, are identical. If then the filtered and unfiltered erythemas are the same, the only difference being in the number of rays reaching the skin, thus increasing the time, why is it that a filtered dose is five or ten or any other number of erythema doses? The fact remains that *biologically filtered and unfiltered erythemas* are *identical,* as exemplified in Experiment No. 2, illustrated in Fig. 2; that 1¼ skin units unfiltered = 5 H or one erythema dose, also that 2½ skin units filtered or one filtered erythema dose.

14. "By increasing the thickness of the filter and decreasing the spark gap the time necessary for a filtered erythema dose, namely 2½ skin units can be progressively increased. *Although decreasing the spark gap in unfiltered dosage lengthens the time of exposure for an erythema dose,* the time ratio between the lower voltages and the thickness of the filter is many times greater than those of the higher voltages. Therefore, one might select a formula with a very low voltage and be able to say that one gave forty or fifty erythema doses.

15. "If then, in describing the *technique of filtered dosage* we adopt 2½ skin units as the standard for an erythema dose, we can use it with the same degree of accuracy as we have the erythema dose of unfiltered dosage."

Among the lessons learned by the early

roentgenologists at the price of bitter experience the one that stands without modification to-day is stated in paragraph 1. The "fallacy" is solely in the proposed explanation by these authors.

When the voltage at which a tube is operated is *reduced, rays of all kinds* (i.e., of all wave lengths) *emitted by the tube are decreased* in intensity, none whatever are increased, many are reduced to nothing. The static machine gives a larger percentage of *short* wave lengths than a coil operated at the *same spark gap*. It may also be remarked that if one operates a coil with inverse through the tube the milliampere reading will be the difference between direct and inverse so that one might even have the meter read zero and yet operate the tube. In such a case we surely would have excess dosage. But now the authors introduce experiment and then interpretation as in paragraph 7. There is here exhibited a common confusion of mind in the use of the term *quality of x-ray*. If a tube operated at a 4½ in. gap, emitted only one (ray?) i. e., one wave length, l_1, and at a 9 in. gap it ceased the emission of l_1, and substituted a new, more penetrating ray of wave length l_2, and if these carried the same energy the "much longer" contention claimed as a prediction from the theory would be well founded. But the facts are entirely otherwise, and the so-called "reverse" only shows a misconception of well founded laws. There are rays at a 9 in. gap more penetrating than *any* at a 4½ inch, also *all those present at a 4½ inch gap are present in increased intensity at a 9 inch gap*.

On account of the smaller percentage absorption of the rays of higher penetration that are *added* when the operating voltage is raised one should not expect that the time for erythema would be reduced to one-fourth by doubling the gap but the writer believes that it is reduced much more than stated in the article quoted.

Paragraph 8 is the most dangerous misstatement relating to *x*-ray therapy that the writer has read in a long time. To say that the absorption of waves of long length has *little* to do with biological effects is to contradict all experience. Again experiment and explanation. Two doses, equal according to the belief of the authors were given to a back and a photograph taken. Suppose they had given 8 min. or 9 min. with filter and 25 sec. or 40 sec. instead of 33¾ without filter, would the photographs have been different? In other words how accurately does equality of negative density or even the unaided eye as a measure of erythema indicate dosage? And if accurate enough for skin therapy are they good guides for deep therapy? Also the writer sincerely hopes no one will use a *9 in.* gap and a *6 in.* target skin distance.

In 12 we again see lack of perception of the real facts. It is true that the quality of the beam *before* filtration was the same in the two cases, also the filter did reduce the quantity of all wave lengths reaching the skin, but the reduction is enormously greater in the long wave lengths so the quality of the radiation *reaching the skin in the two cases was very different*. The only remark which we might agree with is the objection to describing dose by the number of X or H units or multiples of erythema doses.

Now it is true that the same skin effect may result from the absorbtion of equal quantities of radiation irrespective of the actual wave lengths, but the effect is never confined to the skin alone. Thus, glands are often affected to a greater extent than is indicated by the skin reaction. The patient, not simply the patient's skin, is treated.

The article in this JOURNAL (October, 1920, pp. 485-492) contains the same errors as those already cited, in fact in the main it is a rearranged reprint of the others; note the second column of page 488 and the difficult expression as to gaps on page 489.

Whether or not doses of filtered radiation such as described by these authors are both useful and safe must be left to the experience of those who use them. But to base dosage on a method that is so much at variance with well established physical laws, and giving readings inconsistent among themselves, re-

quiring such a vast amount of useless arithmetic can only lead to confusion.

Why cumber our literature with all sorts of units such as H, skin units, ½ H, Hampson units, X units, etc. No one conversant with any of these units can fail to realize the difficulties in their use. While transformers and high tension rectifiers are not perfectly comparable one with another, yet if the rectifier is properly set and the milliammeter is reasonably correct, dosage can be quite accurately reproduced.

If experience shows that a patient having a given disease is most benefited on the average by using a certain current, sp. gap, distance, exposed area, filter and time, that *specifies how to attain* the desirable dose. If the first four are constant the gap being selected properly and reasonable current and distance used, let us assume that half this dose is given when the time is halved. Then when quarter or other fractional doses are prescribed there is only one factor to divide and we have no cumbersome formulae giving a fictitious appearance of accuracy.

Finally it will probably be found that discrepancies between physical laws and amounts and quality of radiation as estimated by color changes, etc., are due either to incorrect exposition or understanding of physics or to defects or limitations in the methods of measurement. In fact the writer ventures to predict that rational radiation therapy will finally be based on the physical laws of radiation. The application of such radiation will ultimately be perfected by reference to the cumulative experience of those who apply these laws properly.

Only when dosage measurements are expressed in a common language, using terms capable of exact meaning can we hope to have the present chaotic condition clarified so as to realize at once the ultimate value and the equally important limitations of this therapeutic agent.

Again I wish to call attention to the reason for this criticism. I am questioning neither the therapy nor the care or skill in reading pastilles of the authors. Whether one should use filtered or unfiltered radiation, 6 or 12 inch spark gap, one minute or one hour, is not for me to say and I surely would not discuss such matters in print. But what therapists will do with radiation depends very much on their conception of the physical side. The extension to higher or lower voltages and choice of filters ought to be based on correct use of the physics involved, to the end that therapists may secure reproduction of results, or, failing that, may be sure that the differences are due to the patient and not to the radiation utilized.

TRANSLATIONS & ABSTRACTS

Kingery, Lyle B., Ann Arbor, Mich. Saturation in Roentgen Therapy—Its Estimation and Maintenance. (*Archives of Dermatology and Syhilology,* April, 1920.)

Two widely separated methods of administrating radiation with *x*-rays have been in use since the discovery of roentgen rays; the older method by which the maximum effects are gradually obtained by the administration of small doses, repeated at short intervals, and continued over a long period of time ("fractional dosage"), and differing radically, the more recent method of "massive dosage," by which the maximum effect is obtained at once. It is to be seen, as the writer points out, that in each method the maximum effect is either preceded or followed by a stage during which the tissue effects are not definitely shown. In the older method this occurs during the period before cumulative effects result in erythema. In the method of massive doses, a period of indefinite influence follows the original maximum effect.

Each cell which has absorbed roentgen rays undergoes a biochemical change, which may produce on appreciable effect, or may result in stimulation, inhibition or erythema, according to the quantity of radiation absorbed. Presumably this sequence of stimulation, inhibition and destruction always occurs; it may precede the erythema resulting from repeated small exposures, or it may follow in the reverse order, the erythema consequent to a single large exposure. In other words, the effect produced will vary according to the amount of rays absorbed by the cell, and one aspect of our problem becomes the maintenance of the optimum quantity in the cell.

This depends upon the rate at which the effects of the rays are lost. Depending on this rate is the frequency with which exposures may be repeated, and the quantity that may be administered at each exposure. The author assumes that tissues exposed to *x*-rays lose that effect in a constant manner. The greater the concentration of the biochemical products of irradiation, the higher the velocity of loss is borne out by certain observations. If this be true, and if we may assume that the rate of loss varies directly as the concentration of some hypothetical decomposition product, then as this concentration decreases, the velocity of loss will become less in the same ratio. Thus, at such time as this concentration has decreased by one half, the corresponding time rate of loss shall have become less by a corresponding amount, and so on, until the residual effect has become negligible. This rate of loss, theoretically, would represent a logarithmic curve and may be so calculated. Such a curve has been established for many chemical and biologic reactions, which we know as "mass reactions," and if we may be permitted to draw an analogy, the biochemical change resulting from the absorption of roentgen rays by tissue elements may follow a similar law.

Proceeding upon the basis of the above hypothesis, that the decreasing residual effects of roentgen rays follow a logarithmic curve, a series of experiments were undertaken by Kingery. He found that a full dose could be repeated after an interval of fourteen days without producing unfavorable complications. Trying, then, the interval at which 75 per cent and 50 per cent could be given, he found it to be seven and three and a half days respectively, that is, at the end of seven days, 75 per cent of the original dose could be given without unfavorable reaction, and at the end of three and a half days, 50 per cent of the original dose could be given. From these intervals, a curve was constructed showing the intervals at which a condition of "saturation" diminished until there is little effect remaining in the tissues. By consulting this chart or curve, it is possible at the end of four, five, six days, or at the end of any interval less than two weeks, to determine the percentage of the original dose given to bring the tissues irradiated back to the same point of saturation previously administered.

In conclusion Kingery enumerates the advantages of this method:

1. Accuracy with which desired irradiation effects may be obtained and continued.

2. Avoidance of stages of incomplete saturation, perhaps of questionable influence, by properly measured doses at proper intervals.

3. Ability to duplicate accurately effects after various time intervals, even by different operators.

4. Constant protection of patients from the results of improper time and dose relations.

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THE INTRALARYNGEAL APPLICATION OF RADIRM FOR CHRONIC PAPILLOMATA*

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THE purpose of this paper is to describe the treatment of intractable papillomata of the larynx with radium. The patient on whom this was used is now thirty-eight years of age. Ten years ago she noticed that her voice showed signs of huskiness; soon a complete aphonia developed. She was treated by her family physician and a local laryngologist for a period of two years; at the time I first saw her, she had had a loss of voice for over two years.

Laryngological examination showed that the lumen of the larynx was occluded with papillomatous masses. These partially covered the epiglottis and the false vocal cords. An attempt was made to remove the neoplasm with forceps introduced through the Jackson laryngoscope. On account of the difficulty in hyperextension of the neck, owing probably to shortness of the cervical ligaments, it was found impossible to operate satisfactorily with the direct laryngoscope. Repeated attempts were made, both under local and general anesthesia, to obtain a direct view of the larynx, but these were all unsuccessful. A number of pieces were removed by the indirect method of the laryngoscopic mirror and curved forceps, after which prolonged local treatments were given. The whole category of chemical escharotics usually recommended for this condition was employed. The growths, however, speedily recurred. In fact, incomplete operation seemed to stimulate the neopiasm.

Accordingly, it was decided to do a laryngotomy, as the obstruction was becoming so pronounced. An incision was made and the larynx split, the growths were completely removed by the curette, and the seat of operation was thoroughly cauterized, after which the larynx was closed. Microscopical examination of the pieces removed showed that the growth was a benign papilloma. Recurrence, however, took place in a few weeks, with the return of so much obstruction that an emergency tracheotomy had to be performed. After the tube was inserted and the breathing relieved, the patient received a thorough course of *x*-ray treatments, but no beneficial effect was noted.

During the writer's absence in foreign service, the patient made two trips to a well-known western surgical center, where two unsuccessful attempts were made to introduce the direct laryngoscope. Inasmuch as it was impossible to remove the growth surgically, the patient was treated by applying radium externally. There resulted, however, no diminution in the size of the growths.

On the writer's return, examination of the

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

patient showed that the epiglottis was completely covered on its posterior surface with villous excrescenses, and the interior of the larynx could not be seen, the opening being blocked by the growth. Neither the false nor the true vocal cords could be distinguished. The patient, at this time, had worn the tracheotomy tube continuously for a period of five years. During this time, she had given birth to two children, with no seeming inconvenience from the constant wearing of the tracheotomy tube.

In considering the case from its various aspects, it seemed futile to attempt further surgical treatment, and as the *x*-ray and external application of radium had been unsuccessful, it was decided to attempt the introduction of the radium capsule into the interior of the larynx. The introduction of the capsule with laryngeal forceps presented certain difficulties, as did also the introduction of the radium capsule on a semi-flexible bougie. Accordingly, the tracheotomy tube was removed for a few minutes and a small, flexible bougie was introduced into the trachea, the bougie was passed upward through the larynx and seized by forceps and drawn out through the mouth. A strong thread was then attached and pulled down through the larynx and out through the tracheotomy opening. The radium capsule, with its rubber filter, was then attached to this ligature, and pulled downward by the thread until the capsule was seen by the mirror to be wedged in the superior opening of the larynx. Twenty-five miligrams of radium placed in a rubber filter were allowed to remain in position of one and a half hours. The patient was given a preliminary dose of morphia to quiet the cough resulting from the introduction of foreign material in the larynx. The tracheotomy tube was re-introduced and the lower end of the thread was attached to the tube, while the upper end of the thread was anchored to one of the teeth. In this way, the radium capsule was held immobile during the hour and a half of treatment.

Considerable reaction followed the first séance, but at examination about one month later it was found that the epiglottis was practically clear of papillomata. At the second séance, the radium capsule was drawn well down into the larynx, with the dosage of twenty-five milligrams for one hour. This was followed by only a mild reaction, and partial disappearance of the laryngeal growths. The true and the false vocal cords then became visible.

A third treatment was given after a period of two months, with a similar dosage.

After three treatments, the patient's larynx was practically free of growths, although a few small tags remained, which will be subject to further irradiation. During the past week, a letter was received from the patient in which she states she is now able to dispense with the tracheotomy tube for one-half day at a time.

In presenting this case for discussion, and in giving the case history, we believe that we have, in the intralaryngeal application of radium, a powerful agent for the destruction of chronic, recurrent laryngeal papillomata.

From the laryngological standpoint, papillomata may be divided into two great groups; first, those which are easily amenable to surgical treatment and which do not tend to recur after removal, and, second, those which show a remarkable tendency to recurrence even after the most thorough surgical removal and cauterization. It is in the treatment of this second group of cases, which fortunately are somewhat rare, that the above procedure is recommended.

"Rapid and extensive recurrence in histologically benign form is observed especially in children, and illustrates the remarkable regenerative powers of the laryngeal epithelium. Laryngotomy and excision or cauterization has been performed three, four, and even seven times in a relatively short period before the disease could be arrested (Wilkinson, Lendon, Clubbe). In this group of cases, radium treatment has given excellent results." Ewing, *Neoplastic Diseases*.

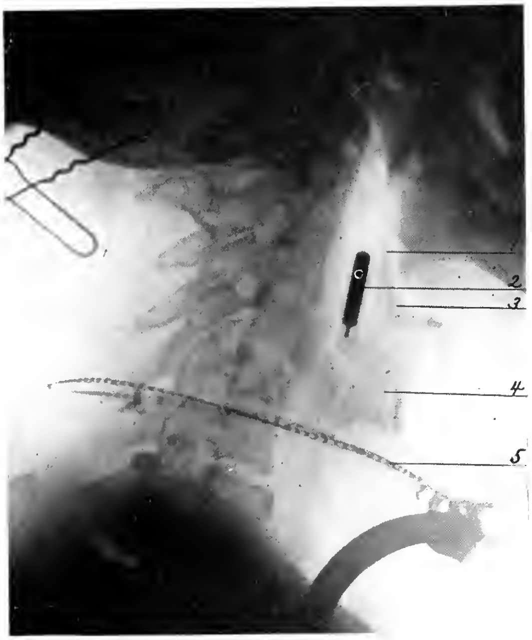
From a purely theoretical standpoint, owing to the slight ability of the radium rays to penetrate tissues, it would seem useless to apply radium externally to the larynx, and

this was found to be true in this particular case. The procedure here recommended, viz., the introduction of a stout thread through the laryngeal and tracheal opening and the immobilization by this means of the radium capsule in the larynx, offers we think a practically sure method of cure of these hitherto intractable cases.

With regard to the technique employed, it is necessary thoroughly to cocainize the laryngopharynx and also the trachea through the tracheotomy opening. At the same time, the patient should be given enough anodyne to keep the cough reflex in abeyance. The observation of the position of the radium capsule in the larynx was difficult when the ordinary laryngeal mirror was employed. Accordingly, it was found more practicable to place the patient before the fluoroscope and, after orientation of the shadow of the epiglottis and of the glottic opening, the position of the radium capsule could be accurately determined. If the capsule was placed too high, it could be readily drawn down by traction on the ligature through the tracheotomy opening. This procedure was found to be much more comfortable for the patient and far more accurate than observation with reflected light. In the introduction of the bougie, it was found much easier to introduce the bougie from below upward, making use of the tracheal opening.

Since the employment of the intralaryngeal applications in this case, the writer has had the opportunity of using the radium capsule in an advanced case of carcinoma of the larynx, where a tracheotomy had been performed for the relief of obstruction to breathing. In this case, it was difficult to introduce the bougie through the tracheotomy opening up into the larynx. Acordingly, the tracheotomy tube was reinserted with the tracheal end pointing upward, this permitting the bougie to pass upward into the larynx. This procedure had to be performed expeditiously, inasmuch as the patient's respirations were, of necessity, cut off.

While the observations on the effect of the treatment of carcinoma by the radium capsule are as yet incomplete, the fact remains that it is perfectly feasible to retain in this way any desired quantity of radium in intimate contact with the diseased tissue for any length of time desired.



1. Epiglottis.
2. Radium Capsule.
3. Hyoid Bone.
4. Thyroid Cartilage.
5. Chain for Retaining Tracheotomy Tube.

Where it is not desirable to perform a preliminary tracheotomy, it is possible to use an intubation tube having a groove cut in its side for the holding of the radium capsule. The method described above, of intralaryngeal application is only put forward as a suggestion for treatment in cases where all other methods have failed.

OBSERVATIONS ON THE BEHAVIOR OF THE NORMAL PYLORIC SPHINCTER IN MAN*

By C. W. McCLURE, M.D., and L. REYNOLDS, M.D.

BOSTON, MASSACHUSETTS

EXPERIMENTAL studies on the physiological factors influencing the motor functions of the gastro-intestinal tract and the relation of these motor phenomena to the digestion and absorption of food products have been largely carried out on animals. But the results obtained from such studies can be applied only in a general way to the physiology of the digestive tract in man. It follows that more intimate knowledge concerning various phases of the physiology of the alimentary canal in man would aid in the interpretation of results obtained from experimental studies of the pathological physiology of human digestion. For this reason certain phases of the motor functions of the normal stomach in man were studied. The present preliminary report largely deals with work bearing on the question of "acid control" of the pyloric sphincter in man.

Cannon elaborated the theory, suggested by Pawlow among others, that acid controlled the action of the pyloric sphincter in animals. In epitome this theory is that the presence of acid in the antrum of the stomach causes relaxation of the pyloric sphincter, while the presence of acid in the duodenum causes the sphincter to contract. The evidence on which this theory is based was obtained from experiments carried out on animals. Phenomena occur in animals which the theory of "acid control" does not explain, and for this reason other controlling factors are assumed to exist. Whether or not acid or some other factor exerts the principal control over the pyloric sphincter in man has not been demonstrated, and with the problem the present investigation is concerned. The results obtained by previous investigators will be discussed later.

The object of the present study has been to determine:

1. The degree of contraction of the pyloric sphincter when foodstuffs partially fill the normal stomach.

2. The behavior of the sphincter relative to the passage of carbohydrate, protein, or fatty foods from the normal stomach into the duodenum.

3. The effect on the pyloric sphincter of direct application of hydrochloric acid and sodium bicarbonate solutions to both its antral and duodenal ends.

These observations of the stomachs of normal persons were made by means of the fluoroscope after feeding meals composed of thick porridge and barium or 140 gm. of ground lean meat and 4 gm. of barium sulphate baked into a loaf, or 120 gm. of ground fatty bacon, 5 egg yolks and 40 gm. of barium sulphate baked into a loaf. The protein and fatty meals were of constant bulk and consistency.

1. *The degree of contraction of the normal pyloric sphincter.*— That the pyloric sphincter is closed when fluid food is in the stomach, except during the periods in which it opens to permit the ejection of food into the duodenum, was demonstrated in 1913 by Cole. His observations were so readily and easily confirmed by fluoroscopic studies that they are now universally accepted. The authors have confirmed Cole's observations by means of the fluoroscope a large number of times. Further evidence that the normal quiescent sphincter is in a state of contraction is afforded by the fact that barium mixtures can be forced from the stomach into the duodenum only by the use of consider-

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

able pressure on the abdominal wall and only when the sphincter has opened in relation to the advance of an antral peristaltic wave. When this is successful the filled antrum and first portion of the duodenum are seen to be connected by a narrow isthmus of barium, which represents the lumen of the sphincter; on cessation of pressure this narrow isthmus disappears.

2. *The behavior of the pyloric sphincter relative to the passage of carbohydrates, protein and fatty foods from the stomach into the duodenum.*—In the routine clinical *x*-ray examination of the stomach a carbohydrate meal consists of 500 c.c. of malted milk solution in which 90 gm. of barium sulphate are held in suspension by the aid of potato starch. The meal starts through the normal pyloric sphincter immediately or within a few minutes after it has been ingested. The normal sphincter opens regularly, as each antral peristaltic wave approaches, and permits the passage of the barium meal into the duodenum over a period of about ten seconds. In two young men with normal stomachs the same phenomenon occurred after the ingestion of thick oatmeal porridge mixed with barium. Except in abnormal conditions accompanied by pylorospasm, opening of the pyloric sphincter at irregular intervals, as described by Cannon in cats, was not observed. The regular opening and closing of the pyloric sphincter, except in the presence of pylorospasm, is so well known that no further work on carbohydrate meals was deemed necessary in the present investigation.

Observations on the behavior of the pyloric sphincter after the ingestion of protein food were made on eleven young men, ten with normal stomachs, one with a quiescent duodenal ulcer, and one woman whose stomach was normal.

Similar observations were made after the ingestion of fatty food in six normal young men. The duration of each experiment varied from thirty minutes to six hours. In these experiments the food was seen to pass from the stomach into the duodenum in normal amounts as each peristaltic wave approached the pyloric orifice. By normal amounts is meant that quantity of barium which passes through the pyloric sphincter after the ingestion of the barium meal commonly used in an *x*-ray examination for diagnostic purposes. The amounts of foodstuffs and of water fed in these experiments formed a very thick mush when thoroughly mixed together in a mortar. To obviate the criticism that the consistency of the food permits it to act more like liquid than solid foods, the meat and fatty meals were administered without the addition of water. The result obtained was the same, namely, the foodstuffs began to pass through the pylorus immediately.

Our observations seem to indicate that both fatty and protein meals begin to leave the stomach within three to ten minutes after the food has been swallowed. Furthermore, the food passes through the sphincter into the duodenum as each peristaltic wave approaches the pylorus. The amounts of a single food or of different ones which pass through the sphincter during a given time do not vary in the same individual.

3. *The effect of hydrochloric acid and sodium bicarbonate solutions on the pyloric sphincter.*—Solutions of hydrochloric acid and in a few instances of sodium bicarbonate were introduced into the duodenum and the effect on the opening and closure of the pyloric sphincter was ascertained. The behavior of the sphincter was constantly observed through the fluoroscope. The activity of the sphincter was determined by the passage or non-passage of barium from the stomach into the duodenum.

The subjects used were hospital patients whose physical condition at the time of the experiments was considered to be normal. The usual gastric analyses of these patients showed no abnormalities.

The observations on the effect of hydrochloric acid and sodium bicarbonate solutions on the pylorus were made as follows: the duodenal tube was passed subsequent to a twelve hour fast; the tube was allowed to

pass into the duodenum. The time required for the tube to pass from the stomach into the duodenum was variable; at times it was only a question of minutes and at others it required an hour or more. After the tube had entered the duodenum a meal was fed.

The meal consisted of a meat and barium meal either rinsed down with 200 c.c. of water or made in a mush by grinding in a mortar with 100 c.c. of water. In certain cases, where the subject was unable to eat the whole meal prepared, we gave an additional malted milk, potato starch and barium mixture to enable us more completely to visualize the sphincter; however, this was necessary in only two cases.

After the patient was observed a sufficient length of time to determine that the peristaltic waves were orderly and regular we began the instillation of solutions of hydrochloric acid and sodium bicarbonate. In some instances an N/40, in others N/20 and in one case an N/10 hydrochloric acid warmed to body temperature was instilled in from 5 c.c. to 20 c.c. amounts into the first, second and third portions of the duodenum. The time of the instillation was varied in relation to the normal opening time of the pyloric sphincter. In some cases an injection was made just prior to the normal opening time of the pyloric sphincter and this was gauged by the observation under the fluoroscope of the advance of an antral peristaltic wave. In other instances the instillation of 20 c.c. of the acid was begun as an antral peristaltic wave reached the sphincter and the instillation continued until the sphincter had opened and closed several times. In another series of experiments a 1 per cent solution of sodium bicarbonate was used in place of the acid and the pylorus was similarly observed. In these experiments on four individuals no effect was observed on the opening time of the sphincter, the amounts of barium passing through it, or upon its time of closure. It will be seen consequently that the behavior of the sphincter is the same whether acid or alkali is introduced into the duodenum. In a fifth subject the introduction of N/20 hydrochloric acid or of 1 per cent sodium bicarbonate into the first portion of the duodenum produced either complete or partial pylorospasm and vigorous duodenal antiperistalsis. This rather unexpected behavior was subsequently explained by the discovery of a duodenal ulcer. In a subject the introduction of N/20 hydrochloric acid into the third portion of the duodenum produced either complete or partial pylorospasm associated with the development of very shallow gastric peristaltic waves. In one subject a loop of the duodenal tube passed through the sphincter into the duodenum leaving the metal tip in the antral end of the pyloric sphincter. This permitted solutions to escape from the orifice of the tube directly onto the antral portion of the sphincter.

DISCUSSION

Our observations demonstrate that finely divided foods, regardless of whether they are solid or liquid, begin to leave the stomach within a very short period of time. Thus barium was observed to pass the sphincter in the time required for the subject to ingest the meal and be prepared for fluoroscopic observation, which was always less than ten minutes. It was of interest to observe that carbohydrates, fats and proteins behaved alike in this respect—contrary to what one would expect from reports of animal observations. That this phenomenon is true for carbohydrate meals has already been stated. But with the exception of Cole no observations in man of other types of meals have been published, and his publication unfortunately gives no experimental details. The barium meal passed through the pyloric sphincter as each antral peristaltic wave approached that orifice. Cole has previously made similar observations. The opening of the pylorus at irregular intervals, as described by Cannon in cats, was not noted. It was observed that the antral portion of the stomach was quiescent except for peristaltic waves which at regular intervals swept over it. The contents of the antrum were consequently not undergoing a mixing process and

the same food must have remained in contact with the gastric mucosa. Therefore, the surface of the antral mucous membrane would be covered with material of a fairly constant degree of acidity. It is very probable that the reaction of this material is acid. This statement is based upon the following facts:

1. The authors have found in two subjects, after feeding a meat meal, the food when first ejected from the stomach into the duodenum to contain free hydrochloric acid in the strength of N/60 and N/500. The position of the metal tip of the duodenal tube and the phenomena transpiring in the stomach and duodenum at the time the specimen for analysis was withdrawn were determined by fluoroscopic observation.

From the above it follows that in order for the stimulation of acid in the stomach to open, and in the duodenum to close the sphincter, there must be assumed the existence of a very delicate balance between the antral and duodenal reflexes in relation to the presence of the same degree of acidity, the duodenal reflex being much the more sensitive.

McClendon and Meyers and the authors have found the contents of the first portion of the human duodenum to be either neutral or of low acidity. After emptying itself of food just ejected from the stomach the duodenum will, therefore, be practically neutral in reaction, and in the presence of pancreatic juice possibly alkaline. Then if acid in the stomach causes the sphincter to relax, the sphincter should become patent when the duodenum empties itself of food. That this is not the case is demonstrated by the difficulty experienced in pushing barium through the sphincter into the duodenum by palpation of the abdominal wall. In fact, it is probable that barium can be caused to enter the duodenum by this means only when the sphincter opens in relation to the advance of an antral peristaltic wave. From this it follows that, if the pyloric sphincter is under "acid control," then the fact that it opens at regular intervals and normally only in a definite relation to the advance of an antral peristaltic wave makes it necessary to assume either (1) that there is a finely adjusted acid regulatory mechanism in the antral region of the sphincter which produces the proper degree of acidity to relax the sphincter at a fairly exact time in relation to the approach of a peristaltic wave toward the sphincter; or (2) that a comparable mechanism for properly neutralizing the contents of the duodenum must exist. If either or both such mechanisms exist they must be so adjusted as to permit of changes in the rhythm of the time of opening of the sphincter, as occurred in one of our experiments after pouring alkali onto the end of the pyloric sphincter. Furthermore, while the sphincter closes suddenly it remains open an appreciable length of time. Barium flows through the sphincter as an antral peristaltic wave approaches and continues to do so until the wave has spent itself. The sphincter, therefore, does not close as soon as acid enters the duodenum, and the presence of acid we have demonstrated experimentally. If acid in the duodenum causes closure of the sphincter then either (1) the proper degree of acidity must be always developed at a time when an antral wave has spent itself, or (2) a secondary mechanism in some way regulating the reflex must be assumed.

The existence of the various factors outlined are necessary to explain the theory of "acid control" of the sphincter, and their existence has not been proved. The assumption of the existence of these factors renders the mechanism of the control of the sphincter exceedingly complex. It is possible that some other less complicated mechanism may exist in man. The latter has been suggested, but not proved, by Luckhart, Phillips and Carlson. These investigators found that a relation exists between the muscular activity of the antrum and the opening of the sphincter.

In four of the experiments here reported it has been shown that acid introduced into the duodenum did not prevent the opening of the sphincter. These observations do not support the theory that acid in the duodenum causes contraction of the pyloric sphincter. Furthermore, sodium bicarbonate was poured into the duodenum in a quantity

which, judging from the limited observations of the degrees of acidity of the duodenal contents, was sufficient to bring about neutralization. The latter must have occurred in an experiment in which 5 per cent sodium bicarbonate solution was allowed to flow into the duodenum. The carbonate solution was introduced on two occasions in quantities of 10 c.c. and 20 c.c. after the pyloric sphincter had opened and up to the time of its complete closure. Before the introduction of the carbonate solution the chyme was collected as it was poured into the first portion of the duodenum during the latter half of the time the sphincter remained open. This allowed the first portion of the chyme to clear the region of the metal tip of duodenal contents. The concentration of free hydrochloric acid in the chyme was N/500, and of total acidity N/25 (titrated to phenolphthalein). According to the "acid control" theory, the sphincter should have remained patent as long as the duodenal contents in these experiments were alkaline. This it did not do, but was observed to close completely. However, absolute evidence that the amount of carbonate introduced neutralized all the acid in the duodenum could not be obtained, although but little doubt can exist that neutralization was effected.

CONCLUSIONS

Conclusions drawn from the experimental work here presented are as follows:

1. Finely divided carbohydrate, protein or fatty foodstuffs begin to leave the normal human stomach within from three to ten minutes after their initial ingestion.

2. Under normal conditions the human pyloric sphincter opens regularly at the approach of each antral peristaltic wave, allows chyme to pass through into the duodenum during an appreciable length of time, and closes when the antral peristaltic wave has spent itself.

3. The introduction of N/40, N/20 or N/10 hydrochloric acid solutions into the first, second or third portions of the normal human duodenum either produced no effect on the opening of the pyloric sphincter as observed by means of the fluoroscope, or produced effects which were interpreted as the result of abnormal irritation of the duodenal mucosa.

4. Neutralization of the contents of the first portion of the duodenum did not prevent the closing of the pyloric sphincter.

5. The experimental results obtained offer evidence that acid is not the principal factor controlling opening and closing of the pyloric sphincter in man.

LEATHER-BOTTLE STOMACH (LINITIS PLASTICA)*

Report of Five Cases with Remarks on Relationship to Syphilis and Cancer of the Stomach

By LEON T. LE WALD, M.D.

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NEW YORK CITY

In view of the number of recently reported cases of syphilis of the stomach, which simulates in appearance that of the leather-bottle stomach, it seems advisable to revise our ideas of the roentgen diagnosis of this condition.

Despite the difficulty of attempting to differentiate by roentgen methods alone diffuse infiltrating scirrhus carcinoma from syphilitic infiltration, or fibrous infiltration of the stomach, it is, nevertheless, possible to distinguish these cases one from the other in a large enough proportion of cases at least to facilitate and augment clinical diagnosis; and in many instances it is possible to make an absolutely correct diagnosis when taken in conjunction with the Wassermann test.

The leading monographs on leather-bottle stomach have been and are based largely upon clinical, operative or postmortem evidence; but with the addition of roentgen methods of study of living pathology, which permit of diagnosis in life, heretofore not possible, our knowledge of the subject is considerably supplemented.

The term "leather-bottle" appears to be based upon the consistency and thickness of the stomach wall rather than from any definite resemblance to our modern bottles; though the narrowing of the pyloric end of the stomach and a compensatory widening of the cardiac end would seem to be the reason for calling it a "leather-bottle" stomach, after the leathern water bottles of the early Egyptians. Schrumpf (1876) calls it "field-canteen" stomach.

Dr. H. H. M. Lyle[1] in 1911 collected seventy cases, described under the term linitis plastica or cirrhosis of the stomach, and reported a case cured by gastrojejunostomy. This case has been under observation for nine years and is still alive, Dr. Lyle informs me.

Carman[2] (1920) has reported three cases.

From our roentgenologic observation of these cases, it appears that the peculiar type of stomach to which the term "leather-bottle" has been applied may represent any one of three conditions: first, fibromatosis; second, syphilis; third, diffuse carcinoma.

Cases illustrating these three types together with the roentgen findings are reported below:

CASE HISTORIES

Case I. Leather-Bottle Stomach Due to Fibromatosis.— H. O., female, aged fifty. Seven months prior to admission to St. Luke's Hospital the patient noticed a tumor in the epigastrium, which on examination was found to be firm, movable and nontender. There was no complaint of pain, vomiting, nausea, sour eructations or jaundice. Solid foods caused gastric distress followed by some belching of gas; there were several bloody stools but no tarry ones; a loss of forty-five pounds in one year. The general appearance was that of a fairly well nourished, not acutely ill woman.

Gastric analysis, free HCl—0, total acidity —30.

Roentgen examination revealed a deform-

[1] *Annals of Surgery*, Nov. 1911.

[2] Carman and Miller. Roentgen Diagnosis, Diseases of the Alimentary Canal. Saunders, 1920.

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14-17, 1920.

ity of the horizontal portion of the stomach involving about one third of the stomach wall. (Fig. 1). It was very smooth and resembled closely a specific infiltration. Both the greater and lesser curvatures were involved. The stomach emptied at an exceedingly rapid rate, the meal meeting with practically no delay at the pylorus, so that in five minutes the small intestine was filled. The duodenum was slightly dilated. At the cardiac end of the stomach there was some irregularity about the entrance to the esophagus, suggesting infiltration of this region. The stomach practically emptied itself in one hour. At the sixth hour the meal had reached the hepatic flexure. A considerable portion of the meal had been eliminated at the twenty-fourth hour.

A confirmatory examination showed the deformity of the stomach persisting and fluoroscopic examination showed the mass in the abdomen to be related to the deformity of the stomach wall.

Fig. 1. Case I. Leather-Bottle Stomach Due to Fibromatosis. Eight minutes after meal. Deformity of stomach involving greater and lesser curvatures. Irregularity at esophageal entrance indicating infiltration. Microscopic examination showed increase in fibrous tissue but *no evidence of cancer.*

Preoperative clinical diagnosis: Carcinoma of the stomach. At operation the stomach was found infiltrated with a large tumor

mass extending over the lesser curvature from the cardia to the pylorus. Lymphatics dilated, but no enlarged or palpable glands; no epigastric adhesions. Incision made in the stomach just above the pylorus and two small pieces removed for microscopic examination.

Pathologic examination of the specimen taken from stomach wall showed considerable thickening, apparently in the submucosa. The mucosa appeared normal and the serous coat was smooth and shining. The smaller fragment consisted only of mucosa and submucosa. The latter was greatly thickened. There was no evidence of any gross lesion.

Microscopic examination of the specimen showed that there was a very considerable increase in the fibrous tissue of the submucosa. This was very thick, rather dense, contained large fibroblastic nuclei which were well stained and gave the form of cellular tissue. The mucosa was normal overlying this, or in some places was slightly hypertrophic. Blood vessels were only moderately thick-walled, showing comparatively little change. There was no perivascular infiltration, and only very little infiltration of the fibrous tissue, except along the deep surface of the mucosa where there were rather numerous lymphocytes. The pathologic lesion appeared only as a diffuse overgrowth of fibrous tissue.

No cells suggestive of a neoplasm could be detected in the section.

Patient was placed on anti-syphilitic treatment in spite of the negative Wassermann examination. No improvement resulted.

Roentgen examination five weeks after operation and about three weeks after the beginning of treatment showed practically no change in contour or emptying time of the stomach. (Fig. 2.)

Eleven months later the patient returned to the hospital complaining of abdominal distention of two months' duration, combined with a swelling of the legs for two weeks. She was able to take only a small amount of food at a time. There was no dyspnea or cardiac distress; no jaundice, pain or constipation. The lump in the epigastrium was still present. She gained in weight after the operation but then became so weak she was quite unable to walk.

Physical examination: patient fairly well nourished and developed; not acutely ill; no cyanosis, jaundice or dispnea. Abdomen was distended, tense, dull in flanks; fluid was present in epigastrium; irregular, large mass just above umbilicus; no rigidity. Gastric analysis: free HCl—0; total acidity—10.

Fig. 2. Case I. (Same case as Figure 1.) Fibromatosis. Five weeks after exploratory operation and removal of section. Ten minutes after meal. Practically no change in contour or emptying time of stomach.

Fluoroscopic examination showed distinct delay in the esophagus, indicating spasm or organic constriction at the cardiac end of the stomach.

Roentgen examination: the stomach remained very small as noted at previous examination. The greatest transverse diameter of the stomach was only 5 cm. This confirmed the diagnosis of leather-bottle stomach. Greater curvature 3 inches above the umbilicus. At the fourth hour, the stomach was entirely empty. No delay in the ileum.

The colon was sluggish. Most of the meal remained in the transverse portion of the colon at the twenty-fourth hour.

At the forty-eighth hour some of the meal

had reached the sigmoid. Traces remained in the transverse portion of the colon.

The abdomen was aspirated and 10 c.c. of fluid removed. No operation. No medication, except tonic. Rest.

vice of St. Luke's Hospital, New York, by Dr. Samuel Lambert on September 29, 1914, with a provisional diagnosis of gastric ulcer.

History: Patient had suffered from pain and vomiting for two years with a loss of

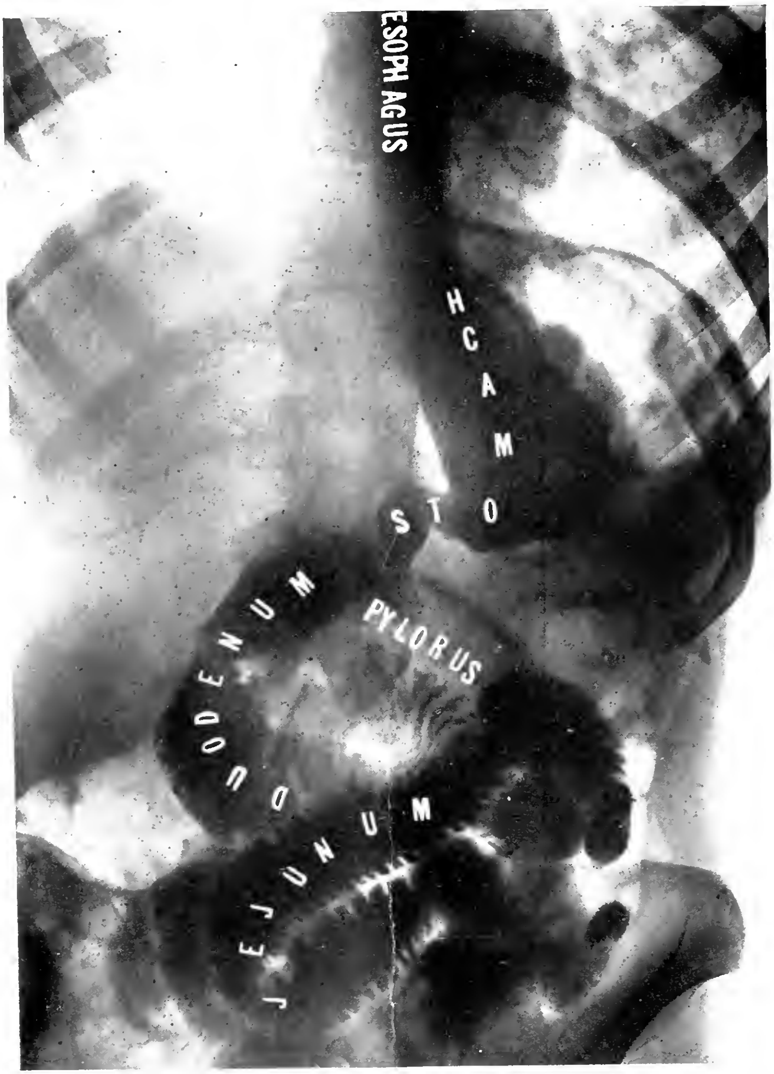

FIG. 3. CASE II. LEATHER-BOTTLE STOMACH DUE TO SYPHILIS. (AGED TWENTY-THREE.) Two minutes after meal. Note diminished size of stomach with compensatory dilatation of esophagus and rapid passage of the meal through the pylorus.

CASE II. LEATHER-BOTTLE STOMACH DUE TO SYPHILIS.[3]—M. A., female, aged twenty-three, married. Case referred for roentgen examination from the medical ser-

fifty pounds in weight. Four months previously she had had a therapeutic abortion performed *for persistent vomiting* and a similar occurrence once before that, three months after her marriage. Whenever she took food she was seized with a sharp pain in the epigastrium followed by vomiting in

[3] This case is one of a group of cases of syphilis of the stomach reported in AMERICAN JOURNAL OF ROENTGENOLOGY, February 1917, iv, 76, by the author.

about fifteen minutes, which relieved the pain. Test meal: blood, 0; lactic acid, 0; free HCl, 0; total acidity, 14.

Roentgen examination showed a peculiar deformity involving the pyloric half of the stomach. (Fig. 3.) This region appeared to be infiltrated, together with the pyloric ring which is held open allowing the food to pass out of the stomach in a most remarkable manner. At the sixth hour there was a small residue high up in the cardiac end of the stomach. Syphilis of the stomach was diagnosed and a Wassermann examination advised. It was reported four plus.

On October 5, 1914, a confirmatory examination was made. This duplicated the finding of a peculiar deformity involving the pyloric half of the stomach causing a considerable narrowing of the lumen, an appearance which is characteristic of syphilis of the stomach. (Fig. 4.) On November 11, 1914, another examination was made after the patient had been placed on anti-spyhilitic treatment following the findings of a positive Wassermann reaction. Nausea and vomiting had ceased and weight had been gained. Roentgen examination showed the peculiar deformity of the stomach persisting and at the sixth hour there was a small residue at the cardiac end of the stomach.

March 1, 1915, patient remarkably improved, had gained forty-four pounds in weight, and was entirely free from pain and vomiting. Roentgen examination showed the deformity at the pyloric end of the stomach still persisting and the stomach emptying at a very rapid rate. (Fig. 5.) At the sixth hour there was a very small residue in the cardiac end of the stomach, very much as in the earlier examination.

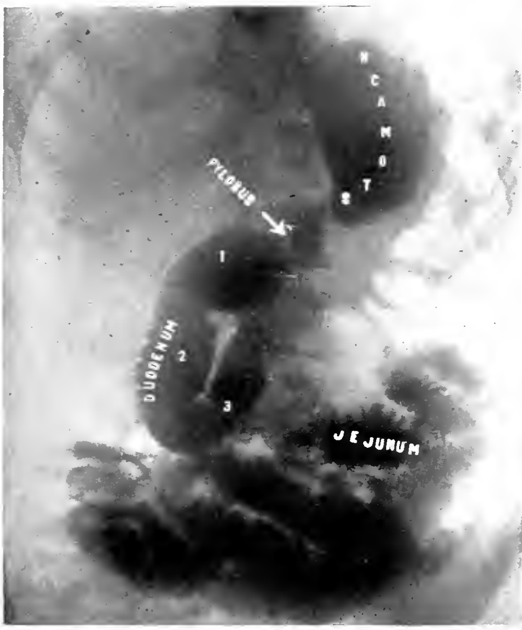

Fig. 4. Case II. (Same case as Figures 3 and 5.) Syphilis. (Aged Twenty-three.) Confirmatory examination. Five minutes after meal.

Fig. 5. Case II. (Same case as Figures 3 and 4.) Syphilis. (Aged Twenty-three.) Five months after medical treatment. Ten minutes after meal. Cessation of symptoms. Increase in size of stomach with less rapid emptying.

February 16, 1916, roentgen examination showed still further improvement in the size of the stomach, indicating some absorption of the infiltration. This was particularly evident about the pylorus, the sphincter having regained its function so that food passed through it at about a normal rate instead of at the excessive rate previously noted. She was free from all stomach symptoms

and had gained fifty-four pounds in weight.

November 20, 1916, gave birth to a healthy child.

Case III. Leather-Bottle Stomach Due to Carcinoma in a Girl Twenty-three Years of Age.[4]—D. V., admitted to St. Luke's Hospital March 24, 1919, with a clinical diagnosis of anemia. Possible cause, carcinoma of the stomach or splenomegaly.

History: four months ago patient began to suffer from indigestion, especially noticeable about one-half hour after meals and lasting from one to one and a half hours. At first there was no nausea or vomiting, but later it was accompanied by incessant vomiting. There was no blood in the vomitus. There was marked loss in weight.

Physical examination; a very poorly nourished adult female, decidedly pale, with drawn features. Abdomen: there was a mass in the epigastrium extending to the left side and palpable two inches below the costal margin. It moved with respiration and had a very distinct edge. It appeared to represent either the left lobe of the liver or the spleen. Wassermann reaction negative. Gastric analysis: free HCl—0; total acidity—0.

Roentgen examination: the fluoroscope revealed a most remarkable condition. The opaque meal passed immediately out of the stomach. The condition resembled very

Fig. 6. Case III. Leather-Bottle Stomach Due to Carcinoma, in a Girl Twenty-three Years of Age. Two minutes after meal. Note dilatation of the esophagus, diminished size of stomach with rapid emptying. Microscopic examination: carcinoma.

[4] This is the earliest age in which carcinoma of the stomach has been observed by the author. A case at the age of fifteen years is abstracted in the *Journal of the American Medical Association*, April 2, 1921.

closely that observed in several cases of syphilis of the stomach. The opaque meal examination confirmed the fluoroscopic findings of a remarkably small stomach with a gaping pylorus. So rapid was the emptying of the stomach that a roentgenogram was made with extreme difficulty, taken while the patient was in the act of swallowing and prone on the table. (Figs. 6, 7, 8.) The stomach as thus outlined measured only about 11 by 3 cm. Eight days later a confirmatory examination was made with the patient in the prone position. A partial filling of the esophagus could be made out, suggesting some attempt at compensatory dilatation to make up for the small-sized stomach.

The patient was operated upon April 23, 1919. The duodenum, pylorus and distal inch of the stomach were apparently normal. Proximal to this was a lump which was sharply marked by a hard indurated line. The stomach was contracted and the walls were the seat of nodular induration which felt carcinomatous to the operator. Surrounding the stomach there were a few hard nodes. The stomach was closely adherent to the under surface of the liver. A jejunostomy was performed and a tube inserted.

Pathological examination. Specimen removed at operation consisted of a small node from the greater curvature with considerable inflammatory tissue surrounding it. It was very firm and white on section.

Microscopic examination of the section showed a considerable amount of inflammatory tissue invading the fat. There was also a small lymph node which was almost entirely fibrous. This fibrous tissue and fat were diffusely invaded by small epithelial cells growing singly or in slender tubules apparently in the lymph vessels. They were only moderately hyperchromatic, the nuclei were rather large in proportion to the size of the cell, although the entire structure was comparatively small. Some of the blood vessels were very thick-walled and the coats were extensively invaded by these small cells. The fat appeared to be actively growing since there were numerous nucleated cells with a pale cytoplasm as well as fat vacuoles without nuclei. Diagnosis: Carcinoma in inflammatory tissue from greater curvature of stomach.

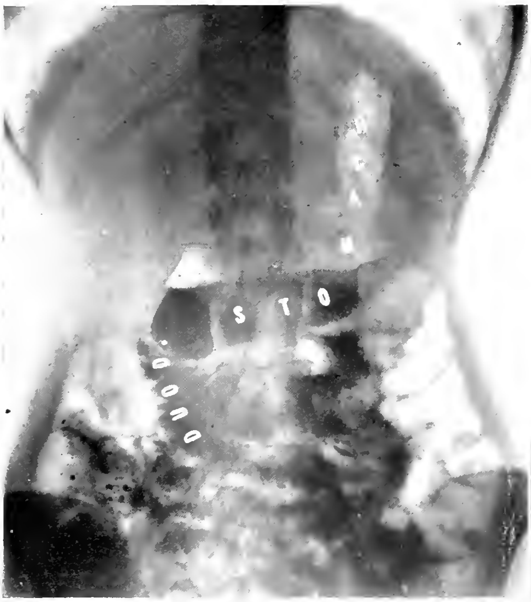

Fig. 7. Case III. (Same case as Figures 6 and 8.) Carcinoma. (Aged Twenty-three.) Six minutes after meal. Meal passing rapidly into jejunum.

Fig. 8. Case III. (Same case as Figures 6 and 7.) Carcinoma. (Aged Twenty-three.) Eight minutes after meal. Stomach almost entirely empty.

In spite of the operative procedure the patient continued to lose weight and strength and died two weeks later. Autopsy revealed cancer of the stomach and the following notes were extracted from the autopsy record: The neoplasm began at the cardia. The cancer extended along the lesser curvature and stopped short about 3 cm. above the pyloric opening. The lesser curvature was greatly thickened. The omentum was firmly fixed to the greater curvature and a little of the fundus remained free from the growth. The pancreas was adherent to the stomach and on section appeared to be normal. The stomach was contracted, measuring but 10 cm. in its vertical axis. (Fig. 9.) The liver showed no evidence of metastatic involvement.

Fig. 9. Case III. Carcinoma of the Stomach. (Aged Twenty-three.) Photograph of stomach showing diminished size and thick wall.

[A fourth case of a very similar-shaped stomach has been encountered and explored surgically and the microscopic examination showed the presence of carcinoma of the peritoneum, but the exact site of the original tumor could not be determined. It probably originated in the stomach. The history is as follows:]

Case IV. Leather-Bottle Stomach Probably Due to Carcinoma.—C. M., male, aged fifty-six. Has complained of stomach trouble for nine months; suffered from vomiting and pain in the abdomen. Admitted to St. Luke's Hospital, July 12, 1919, under the service of Dr. Nathan Green.

Roentgen examination revealed a remarkably small stomach, measuring about 12 by 4 cm. in diameter. (Fig. 10.) The pylorus was gaping so that the duodenum and upper jejunum were filled within a few minutes. There was secondary dilatation of the esophagus. The findings were typical of leather-bottle stomach and closely resembled cases of syphilitic infiltration of the stomach wall. Wassermann was negative.

Exploratory laporotomy was performed

July 22, 1919, by Dr. Green. The abdomen was markedly distended. There was free fluid in the peritoneal cavity. The intestines were matted together owing to numerous adhesions and covered by minute carcinomatous growths. The stomach and transverse colon were matted together so that it was impossible to determine the primary seat of the carcinoma. Both the stomach and the transverse colon were infiltrated with the new growth. The liver was hard and nodular and studded with metastatic nodules. A section was removed for microscopic examination from the infiltrated omentum.

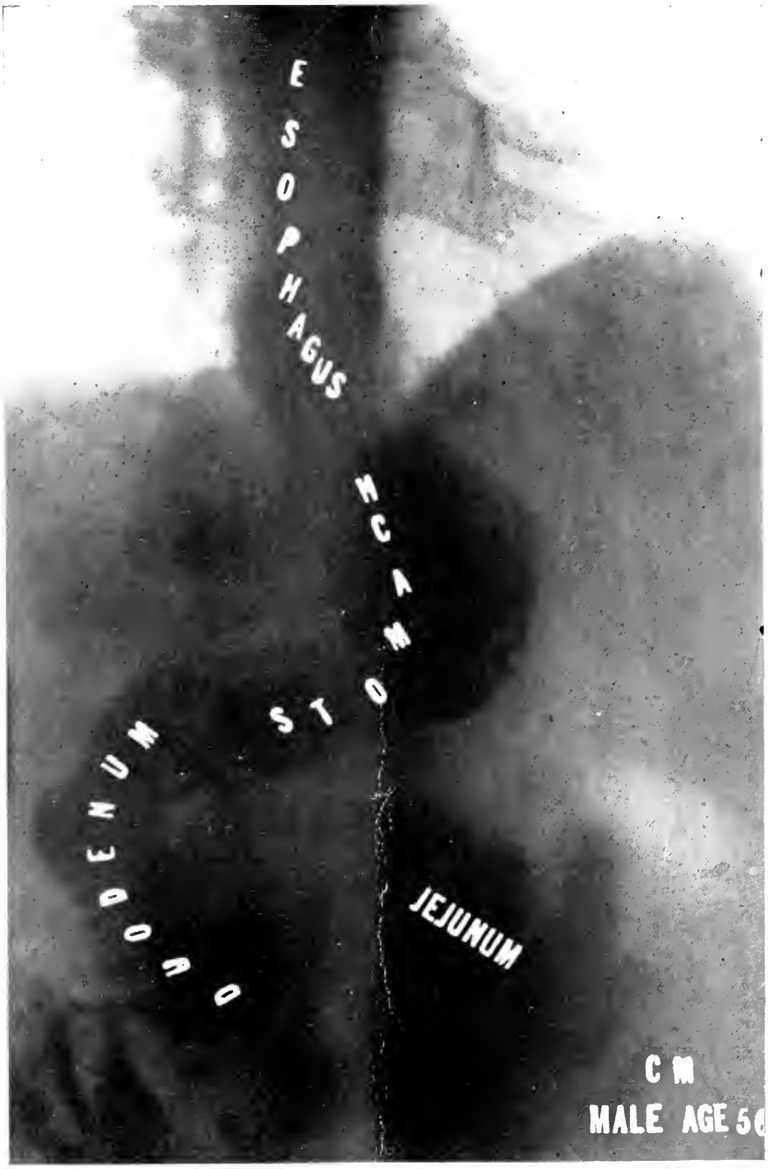

FIG. 10. CASE IV. LEATHER-BOTTLE STOMACH DUE PROBABLY TO CARCINOMA. Fifty minutes after meal. Note small size of stomach with compensatory dilatation of esophagus. Pathologic examination: metastatic carcinoma from abdomen; origin of growth not evident.

Microscopical examination reported by Dr. L. C. Knox. Section consisted of fatty

tissue with extensive productive inflammation and large collections of lymphocytes, and throughout this a few infiltrating carcinomata cells. The cells were rather small and were found in small groups only, but the nuclei were large, hyperchromatic, and showed numerous mitoses. There was no tendency to form glands and no evidence as to the possible origin of the growth. Diagnosis: Metastatic carcinoma from abdomen.

Discharged from the hospital August 7, 1919.

[Note: Just prior to publication of this article an additional case of leather-bottle stomach has been observed. The history is as follows:]

Case V. Leather-Bottle Stomach Due to Carcinoma (?).—C. M., female, aged sixty-three. The patient had suffered from vomiting for several months; no food in the vomitus, just mucus and apparently bile. The vomiting had become almost continuous and was without relation to the taking of food. It was impossible to obtain stomach contents for a gastric analysis. (The reason for this is very evident in view of the rapid emptying of the stomach shown radiographically.) Wassermann negative.

Fig. 11. Case V. Leather-Bottle Stomach Due to Carcinoma (?). Twenty-five minutes. Note small size and dumb-bell shape, very rapid emptying and compensatory dilatation of esophagus.

Roentgen examination: the lower end of the esophagus showed slight dilatation. (Fig. 11.) The stomach was exceedingly small and dumb-bell shaped. (Figs. 12, 13.) The pylorus was gaping so that the entire duodenum and upper jejunum were immediately filled. Moderate dilatation of the duodenum suggested some tendency to com-

pensation for the small size of the stomach. Roentgen diagnosis: leather-bottle stomach —cause not evident.

A confirmatory examination made three days later showed the same appearance. No abnormality of the colon observed.

On account of the continuous vomiting the patient begged for operative relief. March 11, 1921 (two weeks later) a jejunostomy was performed by W. A. Downes. At operation the stomach was found to be greatly reduced in size and capacity, giving a typical leather-bottle appearance. The walls were extensively involved in what appeared to be a diffuse carcinoma. In the middle of the lesser curvature was a contracted area which suggested the site of a previous ulcer. No evidence of secondary nodules in the liver or lymph nodes, so that no material was obtained for microscopic examination.

Further report of this case may be made later.

Fig. 12. Case V. Leather-Bottle Stomach Due to Carcinoma (?). Twenty-eight minutes. Dilatation of duodenum compensating for small size of stomach.

Fig. 13. Case V. Leather-Bottle Stomach Due to Carcinoma (?). Thirty-two minutes. Note dumb-bell appearance still persisting.

CONCLUSIONS

1. The cautious roentgenologist, on encountering a case showing the typical appearance of leather-bottle stomach, will do well to report his findings in detail, but reserve his final diagnosis, stating that the case may be one of three things:

(a) Syphilis of the stomach.
(b) Diffuse carcinoma of the stomach.
(c) Fibromatosis of the stomach wall.

2. The terms "linitis plastica" and "leather-bottle stomach" may well be retained as descriptive of this type of deformity of the stomach, but with a full appreciation of its triple nature.

DISCUSSION

Dr. A. F. Holding. In discussing this paper, we (Jackson Clinic) happen to have a case of linitis plastica hypertrophia chronica, and I thought I would show you the slides and trace the development of this case, which as far as I

know is unique in that it has been under x-ray observation since its start. This case was examined first in December, 1919, and a filling defect demonstrated. I reported a "filling defect which was suspicious," and suggested a re-ray. Dr. James A. Jackson and I examined the patient together fluoroscopically. We got a perfect outline of the stomach, so we thought that the defect previously seen was due to spasm or to pressure of the spine, or something like that. There was no tumor palpable. The case was discharged with instructions to report at the end of three months. At the end of eight months, I found the case had gone to the University Clinic, and that they had made an x-ray examination. Dr. R. H. Jackson was asked for a surgical opinion, and we asked to see the plates. These plates showed a filling defect, constant, which we thought was carcinoma. At this time, there was a palpable epigastric tumor.

This shows the development of this case—eight months before we found first a filling defect, and then were able to exclude it—for by the administration of antispasmodics, we had a normal stomach shadow—no palpable tumor. Eight months later—large, typical, constant filling defect—palpable epigastric tumor.

The case was operated by Dr. R. H. Jackson, and a pylorectomy done. After taking the tumor out he said it cut rather "funny," that it showed a cheesy consistency, and did not cut like a typical carcinoma, that when he cut through it, it creaked like leather. So the specimen was sent to the Mayo Clinic, and they reported back a typical case of linitic plastica. Through the kindness of Dr. Broders, I have been able to obtain slides and photomicrograph of the case, which are here presented. I am indebted to Dr. Curl for the privilege of showing some of these plates.

Dr. L. T. LeWald. A question has been brought up which is still under discussion by pathologists. For example, Dr. Ewing, I believe, takes the stand that all linitis plastica cases are malignant, with the idea that they are carcinomatous, that if you search hard enough, you will find carcinoma cells. However, other pathologists do not agree with this, and among a series of sixty cases reported by Dr. Lyle, you will find statements like the following: "Linitis plastica, malignant type; linitis plastica, benign type," etc. Case I is running a course toward a fatal determination, but whether due to the gastric stenosis or to malignancy is not definitely known.

SELECTIVE ORGAN STIMULATION BY ROENTGEN RAYS: ENZYME MOBILIZATION

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AMONG the numerous biological phenomena which have been studied in connection with *x*-rays and other radiant agents, the effect on enzymes has received considerable attention. Usually such studies have been made by subjecting enzymes *in vitro* to rays of varying intensity. The opinion has been repeatedly expressed that intracellular enzyme activity must be altered following the raying of tissues, and a number of observations have been recorded which relate to this subject. Thus Heile[1] believed that the destruction of the leucocytes would liberate large amounts of proteolytic enzymes and that these liberated enzymes would then be able to attack other tissues. Neuberg,[2] who worked with the effect of radium on tumors, formulated his ideas in the following manner. The radiation causes a destruction of all the enzymes which have to do normally with the anabolic processes of the cell, while those that bring about autolysis are not altered. He showed that rayed carcinoma tissue autolyzed more rapidly *in vitro* than unrayed tissue. A number of other workers have reported experiments similar in character (Packard, Heile, Wohlgemuth, etc.).

So far no experiments have been reported which deal with the actual demonstration of alterations in the titer of the serum enzymes after *x*-ray or similar stimulation. Under the circumstances we thought it would be of interest to determine (a) whether such an alteration in titer does take place, (b) whether variations in the serum enzymes take place when different organs are stimulated, and (c) the influence of different degrees of stimulation on the alterations in titer.

In our experiments we have used dogs rather than the smaller laboratory animals. The larger serum amounts can be withdrawn from them for study without injury; the normal serum enzyme titers more closely resemble those obtained in the human, and in smaller animals the raying of organ groups is technically much more difficult and uncertain. Even in dogs it is of course impossible to confine the rays to any one organ, so that when the liver area is rayed, parts of the pancreas, the gastro-intestinal tract, etc., will necessarily be included to some extent and the results must be interpreted with this consideration in mind. In our preliminary experiments we used large doses (Coolidge tube, 10 inch distance from the skin, 8 ma., 5 to 8 inch back-spark without filter) for periods ranging from fifteen minutes to one hour. With the shorter periods of exposure we found that raying of the liver and intestinal areas resulted in some mobilization of enzymes, but that following the longer periods the titer of the enzymes diminished. We then proceeded with a filter (4 mm. aluminum) and reduced the time of exposure to the following periods—five minutes, ten minutes and twenty minutes, the latter with and without a filter. When so rayed, considerable alterations in the serum enzymes could be determined depending on the area rayed and on the duration of the exposure.

Our studies on the dogs included the nitrogen secretion, the non-coagulable nitrogen of the serum, the leucocyte and differential count, the coagulation time of the blood, the titer of the serum protease, peptidase, esterase (lipase), diastase, the anti-trypsin, and the complement titer. During the course of

the experiments a number of dogs were used for each regional exposure, but in the accompanying chart the average for two dogs has been used.

Nitrogen Excretion.—The animals were kept in metabolism cages and on a fixed diet. With the exception of the periods following the longest liver exposures there was no apparent increase of nitrogen excretion following the x-ray periods in the course of the experiments. Following the twenty minute exposure of the liver area the average nitrogen excretion was, however, increased approximately 60 per cent for a period of four days following the exposure.

Non-coagulable nitrogen of the serum.—This was altered to a considerable extent only following raying of the liver area where an increase of as much as 50 per cent was occasionally determined after raying for ten minutes or more. This increase persisted for several days in such animals. Hall and Whipple [3] in their experiments with lethal x-ray doses obtained such increases with considerable regularity.

The Leucocyte Count.—The leucocytic reaction showed considerable differences with the different regions stimulated. In the following tabulation the normal count taken before the x-ray exposure is contrasted with the average of the counts obtained for the one-half hour, one hour, five hour, twenty-four hour, forty-eight hour and seventy-two hour periods:

Chart I

	Liver		Spleen		Intestine	
Normal	4,000		10,000		3,000	
After 5 min. Exposure		7,600		16,700		3,400
Before	3,200		14,200		3,000	
After 10 min. Exposure		5,600		13,400		8,200
Before	3,400		11,400		7,400	
After 20 min. Exposure		10,000		11,300		12,000
Before	4,800		13,700		14,300	
After 20 min. Exposure (without filter)		8,100		14,300		17,450

In Chart I the effect of the raying on the leucocytes is graphically apparent. It will be observed that following the raying of the liver there resulted a leucocytosis of transient nature; following raying of the intestinal area the effect of raying was a step-like increase until a relatively high leucocytosis (15,000) was maintained. The two dogs used for the spleen experiment commenced with a relatively high leucocyte count (as well as a high serum enzyme titer) and raying did not materially alter the count. The commonly observed leucopenia that follows raying in the human was not observed in this series of animals with the doses that we employed.

Differential Count.—Following the raying of the hepatic area three of four dogs observed showed a well marked eosinophilia. This ranged from 5 per cent to 20 per cent and persisted for a number of days after the exposure. Raying of the intestinal area and the splenic area resulted in general in a diminution of the mononuclear elements and a relative increase in the polymorphonuclear cell forms.

Blood Coagulation.—A number of European observers have recently discussed the increase in coagulability of the blood which they have observed after raying of the spleen. Our observations were made with the capillary tube method and gave us a normal clotting time that varied between three and four minutes. Promptly following the raying of the animals this was usually reduced from one to two minutes, the blood clotting so rapidly that the bleeding of the animals was at times very difficult. In our series there seemed very little difference whether the splenic or hepatic or intestinal area was rayed, the result being apparent no matter what region was stimulated. In studies reported in the following paper it was found that an increase in the thromboplastic substance as well as an increase in fibrinogen occurred after the raying.

The Serum Enzymes Protease.—The proteolytic titer of the serum was estimated by the chloroform method which has been described elsewhere.[4] While open to objections,

it nevertheless seems to give a fair index of the proteolytic capacity of the blood. As will be observed in the chart (the nitrogen digest of the serum is expressed in 1/10 milligrams), raying of the hepatic area increased the serum proteases after the ten minute exposure and the twenty minute exposure. The long exposure when unscreened was no longer effective. Protease appeared in the serum after raying the intestinal area, too, while raying the spleen seemed in general to be followed by a diminution of the originally high titer.

Peptidase.—Peptidase was titrated by allowing varying dilutions of serum to digest Witte peptone and determining the liberation of tryptophan by means of the simple bromine color reaction. Normal dog serum contains practically no peptidase; after raying the liver the enzyme makes its appearance but never to the extent that was observed after raying the intestinal area. Raying of the splenic area was never followed by such mobilization.

Lipase.—Serum esterase was determined by incubating ethyl butyrate with serum and titrating the resulting formation of acid by means of 1/50 NaOH. Moderate doses of *x*-rays seem to mobilize this enzyme after raying the hepatic as well as the intestinal area; raying of the splenic area, on the other hand, seemed to cause a gradual reduction in the amount of lipase in the serum. This was not, however, a constant finding in all of our animals, for in some raying of the spleen was at times followed by a well-marked mobilization of lipase, especially following a single dose of moderate intensity.

Serum Diastase.—The titer of the serum diastase was determined with the Wohlgemuth method of starch digestion by varying dilutions of serum, and the titer is expressed in units (24 hour digestion). Raying of the hepatic area was usually followed by a short sharp rise in the diastase curve. In the chart this does not become apparent because the average for the six bleedings after the *x*-ray exposure was not greatly altered. Raying of the intestinal area did not generally influence the titer, while raying of the splenic area was followed rather by a diminution.

Complement.—The complement titer (hemolytic titer) was followed in a number of animals, but seemed unaffected by the rays in the dosage that we employed. (Not charted.)

Anti-ferment.—Fluctuations in the titer of the serum anti-ferment were quite marked. As a rule the titer increased for a short time following the exposure, then diminished and gradually increased again for from forty-eight to seventy-two hours. The most marked effect followed the more intense periods exposure. (Not charted.)

DISCUSSION

While the clinical development of the *x*-ray and the related radiant agents has been confined largely to the field of diagnosis and local therapeusis, the possibility of remote therapeutic effect has not been uninteresting to medical observers. Among them Edsall and Pemberton [5] endeavored to utilize the effect of the *x*-ray in stimulating autolytic processes by their effort to hasten the autolysis of unresolved pneumonia by means of *x*-ray. Since their publications a number of observers have apparently sought similar applications. Perhaps the work of Manukhine [6] is of particular interest in this direction. Manukhine, aware of the influence that the spleen seems to have in favorably influencing the course of a tuberculous process, found that when he rayed the spleen of tuberculous animals (and patients) the tuberculous process improved. When, on the other hand, he rayed the liver the tuberculous process rapidly extended. He sought to explain the result because of the differences that follow in the leucocytic reaction with the different organs stimulated. While this is not to be excluded, we are nevertheless of the opinion that other factors must be taken into consideration, among them the effect of the serum enzymes which as we have shown in these studies takes place after *x*-ray stimulation.

Other observers besides Manukhine have

taken advantage of the remote effects of x-ray stimulation to bring about therapeutic effects. Drey and Losser[7] have but recently called attention to the effect of splenic x-ray stimulation on bronchial asthma, an effect first observed by Schilling;[8] Stettner[9] has used the stimulating property of x-rays in increasing healing and ossification and has also made the application in the stimulation of glands of internal secretion, as for instance in raying the head to stimulate the hypophysis to promote growth.[10] Stephan's[11] work in studying the effect of splenic raying on the blood coagulating mechanism will be discussed in the following paper.

The regional stimulation of the abdominal organs such as we have reported in this paper may perhaps be of some significance in the study of the intoxications brought about by x-rays and similar agents. Using small laboratory animals Denis, Martin and Aldrich[12] found that intoxication was dependent on exposure of some part of the gastro-intestinal tract and they are of the impression that the intoxication is closely concerned with a reduction of the alkali reserve found by them following raying of intestinal areas. Hall and Whipple[3] regard the intoxication as a protein intoxication following injury of the gastro-intestinal mucous membrane. If the effect is in the nature of a non-specific protein intoxication we must keep in mind that some of the remote therapeutic effects occasionally observed may be closely related to non-specific therapeutic results obtained by other means, such as vaccine, proteose, milk or tuberculine injections.

If pathological lesions are to some extent influenced by the serum enzymes it would seem to us possible that through x-ray organ stimulation or stimulation by other related agents a means of such therapeutic control is offered. We are of course at the present time unable to state definitely whether the metabolism of the normal cell is altered by the alteration in titer of serum enzymes; but where we deal with necrotic tissue it would seem plausible that an increase of the proteolytic serum enzymes would hasten the removal of such material provided that other factors that influence digestion (hydroxyl-hydrogen balance, anti-ferment concentration, etc.) are favorable. It might seem of interest to keep such enzyme mobilization in mind when studying the remote effects of radiant agents, not only where we have to deal with toxic manifestations (x-ray shock, etc.) but also where favorable therapeutic influences are made manifest.

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THE INFLUENCE OF X-RAY ORGAN STIMULATION ON THE COAGULATION MECHANISM

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During the experimental observations on the effect of the *x*-ray exposure of the hepatic, splenic and intestinal areas for varying periods of time as reported in the preceding paper, evidence of a change in the coagulation time of the blood was obtained. A number of recent investigators, observing the reduction of the coagulation time following the raying of the splenic area have suggested that measure for therapeutic use in cases of severe hemorrhage. Stephan[1] for instance reports a case of purpura fulminans in a man of forty-five in which a refractory hemorrhagic diathesis was successfully combated early in 1919 by means of deep roentgenotherapy applied to the spleen. Investigations that he undertook in connection with this result led him to state that roentgen radiation applied to the spleen rapidly decreases the coagulation time of the blood *in vitro,* and increases likewise to a considerable extent the amount of coagulating ferment in the blood serum. Radiation seems to have the same effect on the organism as extensive loss of blood. The essential factor that arrested and cured the hemorrhagic tendency was the increase in the quantity of the coagulating ferment, and this was realized by the action of the roentgen rays on the spleen. He thinks they exert a specific functional stimulus on the elements of the spleen other than the lymph follicles. The blood platelet count does not seem to be modified. The coagulation time was shortened sometimes to one fourth even in normal subjects by raying the spleen; the maximum effect was apparent between the second and fourth hours, and then gradually subsided. His clinical and experimental research demonstrated, he believes, that stimulating the functioning of the spleen by roentgen radiant energy must be regarded as theoretically a true physiologic method of arresting venous and parenchymatous hemorrhages. In numerous cases it proved extraordinarily effectual in practice, far surpassing the effect of any medical hemostatics.

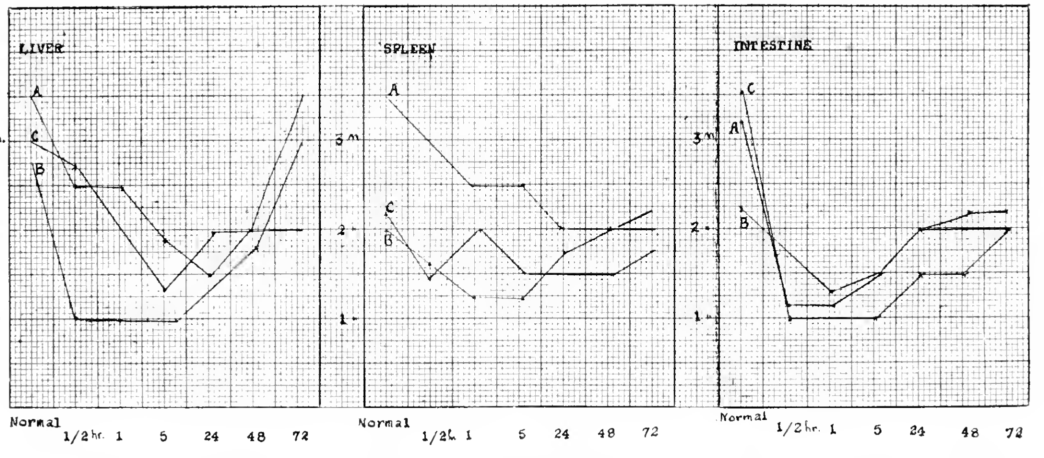

Chart I. Coagulation Time of the Blood after X-Ray Exposure for Five, Ten and Twenty Minutes.

Jurasz[2] considers this observation of con-

siderable practical importance in surgery, and recommends that before operative procedures the coagulation time of the patient be determined, and if it is found delayed, that the patient be rayed from fifteen to twenty hours before the operation in order that the coagulation time be brought within normal limits.

As a matter of fact it is probable that any stimulation of the spleen results in this same effect on coagulation. Thus Nonnenbruch and Szyszka[3] found that simple diathermy of the splenic area would appreciably increase the coagulability of the blood in from one to two hours. The effect was, of course, not quite so pronounced as following radiation. Szenes[4] found that the increase in coagulation occurred not only after raying the spleen, but after raying lymphatic tissues in general.

In a more recent publication Stephan[5] takes exception to the work of Szenes, however, for the reason that his observations were limited wholly to the measuring of the coagulation time, not to a study of the individual factors in the coagulation balance. Thus a lowering of the antithrombin content, or an increase in the platelet count might simulate the results obtained when there is an actual increase in the thrombin.

In view of the practical importance of the subject we have made a detailed study of the alterations that occur in the coagulation mechanism following raying of the hepatic intestinal and splenic area. The observations included the following: clotting time; prothrombin; antithrombin; fibrinogen; blood platelets.

Prothrombin and antithrombin determinations were performed according to the method of Minot.[6] Thrombin was prepared according to Howell.[7] Fibrinogen determinations were recorded according to Wohlgemuth.[8] Blood platelet counts were observed by the Wright-Kinnicut method.

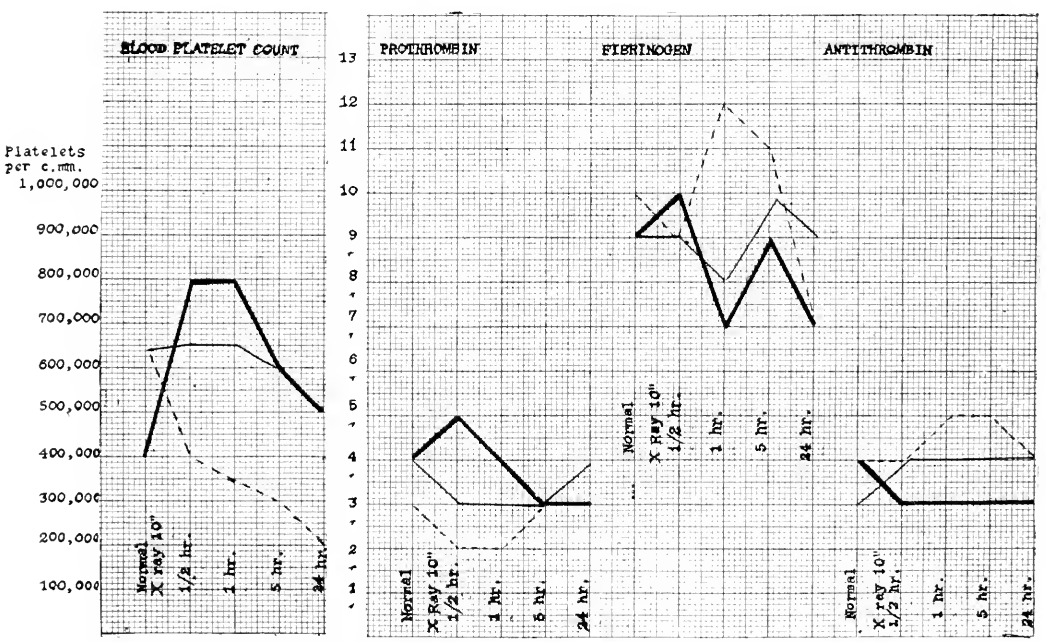

CHART II. HEAVY LINE—Titer after raying hepatic area; DOTTED LINE—Intestinal area; LIGHT LINE—Splenic area.

Dogs were exposed for 10 minutes (Coolidge tube, screened by a 4 mm. aluminum screen, at 10 inch distance, 8 ma. and 5 inch back-spark) over the liver, intestinal and splenic areas. The exposures were made in the morning (serum samples being obtained before) one-half, one, five and twenty-four hours after exposure.

BLOOD COAGULATION.—In studying the coagulation time, capillary tubes drawn out to a uniform diameter were used, the clotting

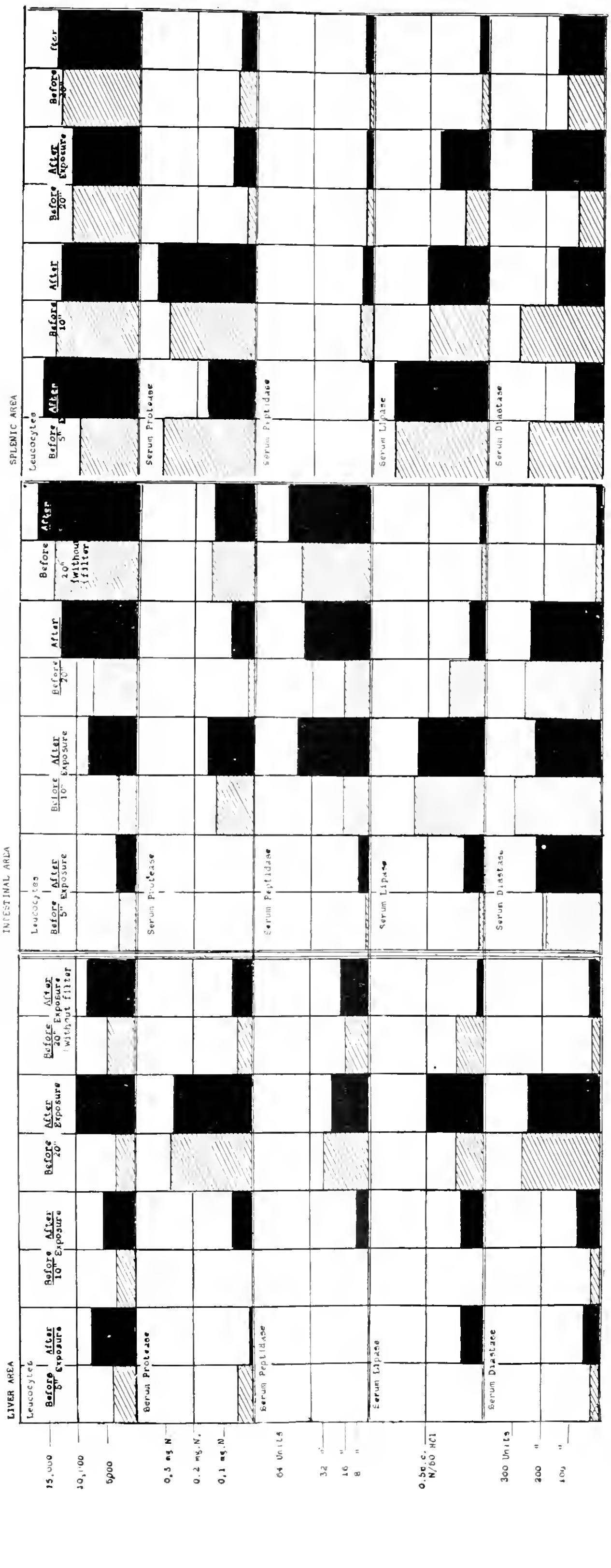

CHART III. Illustrating leucocytic and enzymatic reaction following raying of liver, intestinal and splenic areas in dogs for five, ten and twenty minute periods. The shaded blocks represent the titer before the period of raying, the black blocks the average for the determinations following the raying (serum samples taken ½, 1, 5, 24, 48 and 72 hours after the exposures).

time recorded when on breaking the tube a firm coagulum could be drawn out. In our experiments the most prompt effect on the clotting time seemed to follow raying of the lower intestinal tract; the effect on the clotting time following exposure of the splenic area was more delayed. In the later case, however, the effect on the coagulation especially after longer raying periods was more prolonged. In Chart I the average coagulation time is shown.

In view of the rather decided changes in the coagulation time above noted we anticipated marked alterations in the titers of the coagulating factors in the blood, corresponding to the observations of Stephan. In this we were disappointed. As will be observed in the next chart (Chart II) fluctuations in the various elements of the balance did occur but not to the extent demanded by the marked lowering of the actual coagulation time.

Blood Platelets.—Raying of the hepatic area gave a maximum increase of blood platelets during the one half to one hour period, gradually returning to normal. Raying of the splenic and intestinal areas gave a gradual diminution in the platelet count during the ensuing time periods.

Prothrombin.—Exposure of the liver showed a slight decrease up to the one-half hour sera, with gradual increase in the remaining sera, while the spleen and intestinal exposures showed an increase with a subsequent return to normal. (The curve, Chart II, in which the serum dilutions are charted, represents the inverse of the actual titer of the prothrombin present in the serum. Thus the actual amount following hepatic raying after a slight diminution, was increased, as was also the case after raying the splenic and intestinal areas.)

Antithrombin.—Raying the intestines showed a maximum increase during the one to five hour periods; splenic raying showed a slight increase through to the twenty-four hour sample, while raying of the hepatic area showed a miximum increase during the one

Fibrinogen.—The maximum increase in fibrinogen from intestinal raying was noted in the one and five hour period, diminishing to below normal in twenty-four hours. The splenic raying was followed by a decrease with a maximum increase at the five hour period, returning to normal at the twenty-four hour period. Liver raying showed transitory increase with fluctuating decrease and increase to below normal as noted in Chart II.

CONCLUSIONS

1. Raying of the splenic area in dogs is followed by a diminution in the clotting time of blood determined by the capillary tube method.

2. Raying of other areas (hepatic and intestinal) is also followed by similar changes in the clotting time. The mechanism of the alterations in clotting time may differ following various regional exposure. Thus raying of the splenic area was followed by an increase in prothrombin, some increase in antithrombin, a rather delayed increase in fibrinogen, with little alteration of the platelet count. Raying of the hepatic area was followed by a rather considerable increase in platelet count; raying of the intestinal area by an increase in the amount of fibrinogen.

3. Inasmuch as the effect of the x-ray exposure is quite prompt the use of this measure in surgical cases as well as in the management of medical cases associated with a hemorrhagic diathesis seems a feasible procedure. The clinical success of the x-ray in the treatment of uterine hemorrhage may depend in part on the general effect on the coagulation mechanism.

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AN X-RAY BURN OF THIRD DEGREE FOLLOWED BY RAPID HEALING*

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AN UNUSUAL case of rapid healing of an extensive *x*-ray burn seems of sufficient interest to *x*-ray therapeutists to warrant its formal presentation in detail. Lest the surprising occurrences hereinafter described be doubted by those whose *x*-ray experiences have brought them into contact with similar reactions of unwished for degree with less favorable results, photographic evidence is offered as part of the record.

FIG. 1.

FIG. 2.

Experience in *x*-ray therapy in skin diseases teaches that the first degree reaction is often necessary to bring about a cure in many conditions; it is usually a transitory condition, a reddening or blushing, which soon fades, the skin returning to normal. Occasionally a second degree reaction occurs, in cases in which a first degree change was desired. This often follows an overdose through misjudging the patient's resistance to *x*-ray action. Depending on the size of area involved and the individual's resistance, this superficial skin destruction will be followed by healing which takes several weeks (sometimes months) and disappears, leaving little or no scarring. In some cases such reactions become a serious consideration to the therapist if the healing process be unusually slow. Through accident, an overdose may be so severe as to result in a third degree reaction or burn. This third degree reaction is a far more serious event than the preceding and most often results in a train of developments which gives the *x*-ray therapist immeasurable worry and often mental anguish, as there is so little that one can do for the relief of the condition. The degree of skin and underlying tissue destruction is so great that some such cases will never heal and recourse to skin grafting is necessary. The tissue destruction may extend through the deeper muscles and reach the underlying bone or even go entirely through a part.

An exception to the usual course of events

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in a third degree x-ray burn occurred in a case which was being treated for a very extensive blastomycosis of the lower abdomen.

The patient was a colored male, thirty-seven years of age. He was in good physical condition except for an extensive blastomycotic skin lesion. This lesion was of ten years' duration and began as a small "pimple" on the skin at the perineum. It was of very slow growth and gradually spread in anterior and posterior directions, reaching the posterior limit of the median groove between the nates but not spreading over the buttocks; its greatest spread occurred anteriorly from the point of origin over the entire scrotum, over the shaft of the penis, the glans, and it then invaded the skin over the lower abdomen by way of both inguinal folds, spreading about equally on both sides of the body to the flanks at the regions over the iliac crests. (Fig. 1.)

Fig. 3.

In the ten years of growth the patient had knocked around from doctor to doctor and clinic to clinic but obtained no permanent relief. The lesion continued to spread slowly in spite of all efforts to arrest its progress. He was unable to work and became a public charge. As is characteristic of this fungus invasion of the skin, the edges of the lesion only were the site of the activity; the remaining area already run over by the growth was left a leathery tough hard skin in which all skin pigment peculiar to the colored race was lost and he was seemingly turning a pinkish white. In the zone of activity the lesion itself had much of a cauliflower appearance. This zone was from 4 to 5 cm. in width all along the edges of the involved area.

X-ray therapy was advised by the late Dr. Harris (at that time head of the skin department of the Cook County Hospital) and treatment was begun in September, 1916. In view of the marked chronicity of the lesion and failure of all other therapy to effect a cure, a more than ordinary skin dosage seemed to be indicated. Multiple areas were necessary to cover all the lesion present. The normal skin was protected from the exposure and three circular areas over lower abdomen anteriorly and one over the perineum were radiated, four in all, each three inches in diameter. A formula of 5 milliamperes of current, a 5 inch spark-gap resistance (60,000 volts), at a 7 inch target to skin distance, for five minutes, with 2 milliammeters of aluminum filter, was given. No

Fig. 4.

noticeable changes followed the first treatment. A second dose was given ten days later which was followed in about a week by a noticeable improvement.

Subsequent treatments were given at two weeks' intervals and the lesion continued to improve. After the fifth series the condition was practically healed with but a few spots of activity remaining, which required more treatment. The patient naturally was much pleased at the outcome and relief from his condition. He informed me with much joy that he now, for the first time in ten years was able properly to use toilet paper.

Fig. 5.

Fig. 6.

At this time an enforced absence necessitated that the treatments be given by an assistant whose previous work had been satisfactory. Explicit instructions called for radiating three areas over the abdomen from right to left and the formula to be followed exactly as already described. Area No. 1 was to be given on the right side anteriorly; area No. 2 in the median line anteriorly and No. 3 to be on the left side also anteriorly. Owing to a slip-up in this proceeding, area No. 1 was given which was followed by area No. 2. Then, instead of setting the x-ray tube over area No. 3, the No. 1 area was given a second full dose under the impression that this was the area remaining to be treated. Of course this was not recognized at the time.

In a very short time, the second or third day following, a complete tissue break down rapidly developed in area No. 1, and in eleven days the entire abdominal wall, the skin, subcutaneous and muscle tissues, in the exact area treated, about 3 inches in diameter, had disappeared down to the peritoneum. This alarming event naturally caused much concern. The coils of the intestines could be seen through the thin peritoneum which appeared as a more or less transparent veil. Why this thin structure did not also break down is not explained. The patient did not complain of much pain and seemed the least worried of those concerned. We cautioned all those in his ward not to startle him or in any wise cause any sudden muscular action, for it was feared that the thin wall remaining might rupture, through sneezing or other similar violent movement and thus call for an emergency operation to replace some popped-out colon. He was kept very quiet and a sterile dressing kept in place over the eroded area, binding it firmly and very tightly over the hole in the belly wall. We held our breath, prayed much and feared more, slept but little and went about in fear and trembling. No medication of any kind was given and plans were made for a later surgical repair, if possible. (Fig. 2.)

In fifteen days the broken down tissue had increased but very slightly in extent. (Fig. 3.) During the next few days a surprising

change took place and in one week one hardly recognized the area. The edges had filled in apparently with new regrown tissue, the hole had closed and its size was now about one third of the original area. With wonder we daily observed its progress. We had of course discontinued all x-ray treatment to the small, still active spots which consequently began to spread. In thirty days (Fig. 4) the burn had made further healing progress, had become noticeably smaller and in thirty-nine days (Fig. 5) no definite evidence of the accident was visible. There was no real scar, and but little puckering or drawing in of the healed-over spot.

The remaining areas of revived blastomycotic growth were subsequently treated by x-ray dosage of the same formula as given above, and a complete cure was obtained. No untoward sequelae have occurred since the events here described (three years) and the patient is now working.

Seeking for an explanation of this unusual healing of so marked a tissue destruction, it has been suggested that the area involved was no longer true skin tissue, having been changed by the fungus invasion, and that therefore it responded in a different way from that in which the normal skin responds.

HIRSCHSPRUNG'S DISEASE. REPORT OF CASE

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HISTORY.—Miss F. B., age eight, was admitted to the hospital with the following history. Father is a syphilitic, and mother is now in a sanitarium with active tuberculòsis. Patient normal at birth according to mother's statement. At the age of seven months began to have attacks of constipation, which attacks would last for several days at a time. Her parents then observed that patient's abdomen had begun to distend, and for the following three years had only two stools a week. During one prolonged attack of constipation, patient went into a state of coma, which lasted three days. During this time she had involuntary liquid stools. Drastic cathartics were administered and patient regained consciousness. For the past three years child has been given prune juice and various fruits in addition to her regular diet, which has regulated her bowel action fairly well. Recently, however, the attacks of constipation have become more severe, lasting from a week to ten days. She complains of nausea at times, but does not vomit. Patient has no desire to play or exert herself in any way, as it tends to bring on cardiac distress. She has not lost any weight. She appears to be intelligent, and keeps up well with her schoolmates in her studies.

Examination.—On routine examination, child was found to be normal except for the abdomen. The abdomen was uniformly distended. A palpable mass could be indistinctly outlined on the left side. The patient did not complain of any pain or distress at the time of examination. She was put to bed and an attempt made to clean out the intestinal tract. Quantities of fecal matter were passed following the administration of cathartics and enemas. On the fourth day the patient was sent to the x-ray department.

Roentgen Findings.—Screen examination. Under the fluoroscope the stomach appeared to be somewhat distended for a child of this age. Peristalsis was very inactive. No filling defects were noted. The cap was visualized. The duodenum appeared to be distended with gas.

Plate Examination.—Plates made soon after the ingestion of the meal showed findings similar to those noted above. Six hour plates showed considerable gastric residue, only a small portion of the meal having

passed into the small intestine, which was crowded over to the left of the median line. (Fig. 1.) Twenty-four hour plates disclosed a large residue in the cecum, the ascending and transverse portions of the colon

Fig. 1. Six-Hour Gastric Residue. Small intestine crowded over to the left of the median line.

being well outlined. The transverse colon was deep in the pelvis. Plates made at the termination of twenty-four hours showed a small amount of barium in the cecum and transverse colon. One week later patient was again fluoroscoped, and a small cecal retention was observed. She was put to bed and given daily cathartics and enemas. At the end of ten days, she was given a barium enema composed of 1000 c.c. of water, and 180 grams of barium. This was retained without difficulty. Plates made showed the sigmoid and descending colon to be greatly distended, forming a pouch-like mass which filled the greater part of the pelvis and left abdomen. (Fig. 2.)

For two days following the administration of the barium enema, patient passed quantities of fecal matter and barium. Repeated fluoroscopic examinations continued to show the presence of barium in the cecum, ascending colon and sigmoid. One week later the patient was again fluoroscoped and a small cecal retention was observed.

Diagnosis.—On the roentgen findings and history of the case a diagnosis of Hirschsprung's disease was made.

Operation and Results.—After three days of careful preparation, the case was referred to the service of Dr. Rexwald Brown for operation. Through a left rectus incision, a greatly dilated and thickened descending colon and sigmoid were delivered. Owing to the fact that the dilatation extended into the rectum it was found impossible to perform an end-to-end anastomosis. The distal third of the descending colon, together with the sigmoid and proximal end of the rectum, was resected. This portion of the intestine contained approximately two quarts of liquid feces. The colon and rectum were closed by infolding, and a lateral anastomosis made between the two free ends by means of an oblong Murphy button.

Fig. 2. Enormously Dilated Rectum, Sigmoid, and Descending Colon.

The patient's condition following the operation, and for the first week was excellent, and every hope was held for an uneventful recovery, but on the ninth day she suddenly developed an acute peritonitis. Drainage was of no avail, and the patient expired.

THE DIAGNOSIS OF A BRAIN TUMOR BY PNEUMOVENTRICULOGRAPHY

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IN any large clinic a frequent subject of consultation between the surgeon and the roentgenologist is the question of the existence or the location of a brain tumor.

In only a very small percentage of tumors does the growth cast a shadow on the plate —Dandy in his studies of the subject says 6 per cent. These were tumors with definite calcified areas, and naturally only the calcified portions were visible. Other growths arising from the intracranial structures, being of no greater density than the surrounding tissues, were of course invisible by the ordinary methods of examination. The signs of intracranial tumors so well studied and ably described by other writers are in many cases pathognomonic, but the percentage is still less than one half and the location of the lesion is seldom definite.

Inspired by the work of Dandy we have made an effort in this clinic to follow his technique in a few cases. Our study has been limited to three cases, one child and two adults. In the first case the results were so striking that it seems worthy of report.

A white boy of six years with unimportant previous and family histories exhibited symptoms three years ago which were diagnosed clinically as probable brain tumor, but the roentgenograms gave no evidence and the lesion was never localized. Subsequent course bore out the diagnosis and two years ago an occipital decompression was done with some temporary relief.

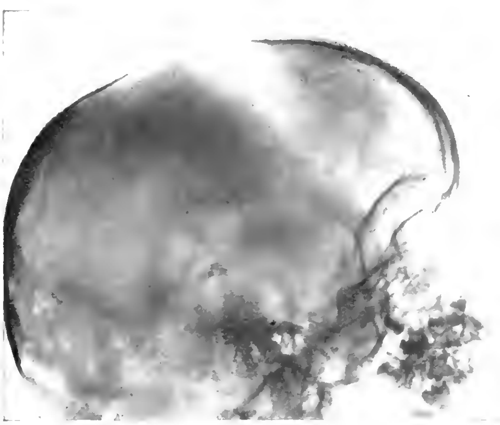


FIG. 1. CASE I. BEFORE INJECTION, SHOWING CALCIFIED AREA.

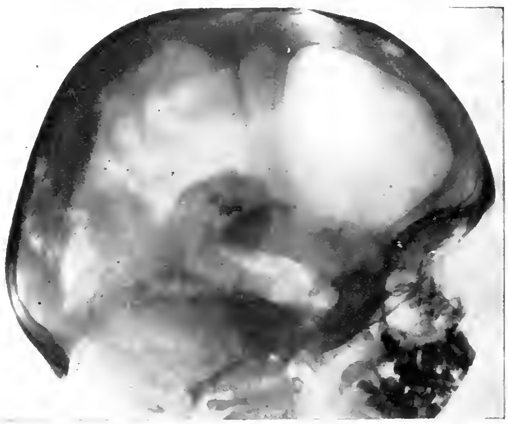


FIG. 2. CASE I. AFTER INJECTION, SHOWING TUMOR SURROUNDING CALCIFIED AREA.

He came to us in an apparently hopeless condition. Radiograms were made in the usual positions. The skull was seen to be unusually large and thin. Mottling of the inner table and changes in the base suggested intracranial pressure. The sutures were wide in the upper portion. Just above the mastoid shadow in the mid-portion of the skull was seen a calcified area of a horseshoe shape apparently in the brain.

With the remote hope of locating an operable lesion the surgeons considered pneumo-

ventriculography. Through a small trephine opening the anterior horn of the right ventricle was entered. A large amount of fluid was released and air was allowed to enter under atmospheric pressure. Radiograms were taken in various positions. The tumor

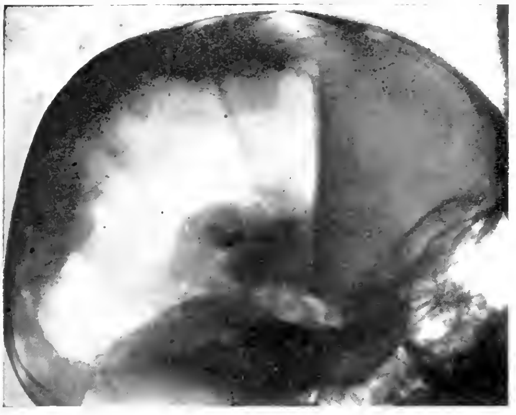


Fig. 3. Case I. Prone, showing Tumor and Fluid Level.

poor condition of the patient it was considered inoperable.

Following the operation the patient's condition grew worse and on the second day after he died.

It is the surgical opinion that the sudden release of so much fluid and great decrease of intracranial pressure may have hastened the course, although the patient was practically in extremis at the time of the operation.

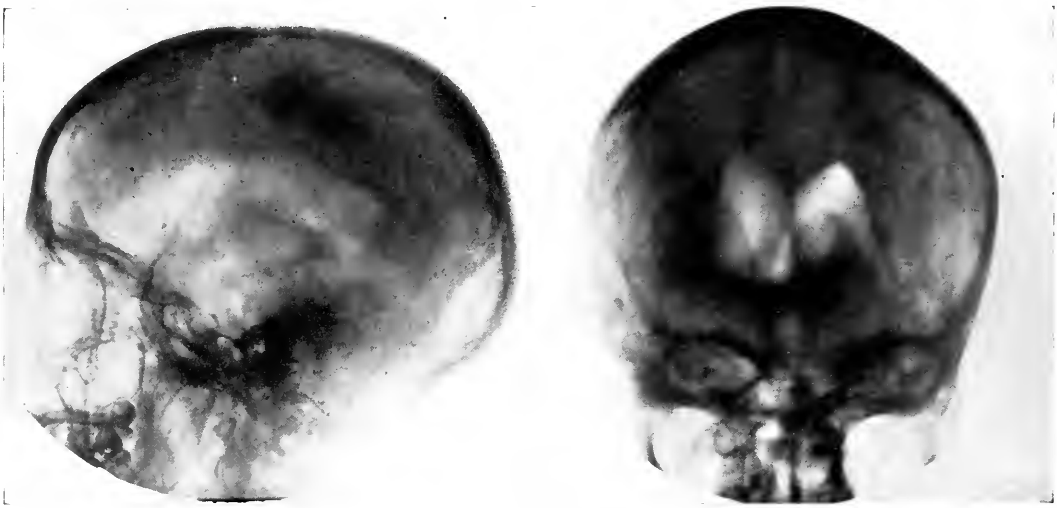
Although the examination failed to help this patient or postpone the inevitable, it demonstrates several valuable points. It shows that intracranial tumors may be made visible. It leads us to believe that in similar cases the examination should be made earlier before the intracranial changes are so advanced. It suggests that where much fluid or great pressure is suspected a measure should be made as accurately as possible of the pressure and the amount of fluid withdrawn.

Fig. 4. Case I. Photograph of Right Hemisphere showing Section of Tumor.

was distinctly seen surrounding the previously observed area of calcification and apparently occupying the site of the pineal body. From its size and location and the and this restored by an equal amount of gas under an equal pressure.

At autopsy the tumor was demonstrated identical with the shadow in the plates and

was found to be a teratoma originating apparently in the pineal body, and containing bone, hair and skin elements. The foramen of Monroe and the aqueduct of Sylvius were blocked by the tumor.



FIGS. 5A AND 5B. CASE II. VENTRICLES PRACTICALLY NORMAL IN SIZE. LATERAL AND THIRD VENTRICLES FAIRLY WELL SEEN. POSSIBLE MASS ON LEFT.

The other two cases were adults. In neither case were the findings conclusive. In one the ventricle failed to be injected. In the other there were suggestions of an abnormal mass, but we found ourselves handicapped by our unfamiliarity with the normal intracranial picture. This case complained of some headache for a few hours, but there were no disturbing symptoms in either case. These cases suggest to us that the operation may be done in selected cases without harm to the patient. We should make ourselves familiar with the normal picture by experiments on the cadaver before we can speak with certainty of small lesions.

The accompanying prints need little explanation.

FOREIGN BODY IN THE BRONCHUS FOR FIFTEEN YEARS

By I. SETH HIRSCH, M.D.

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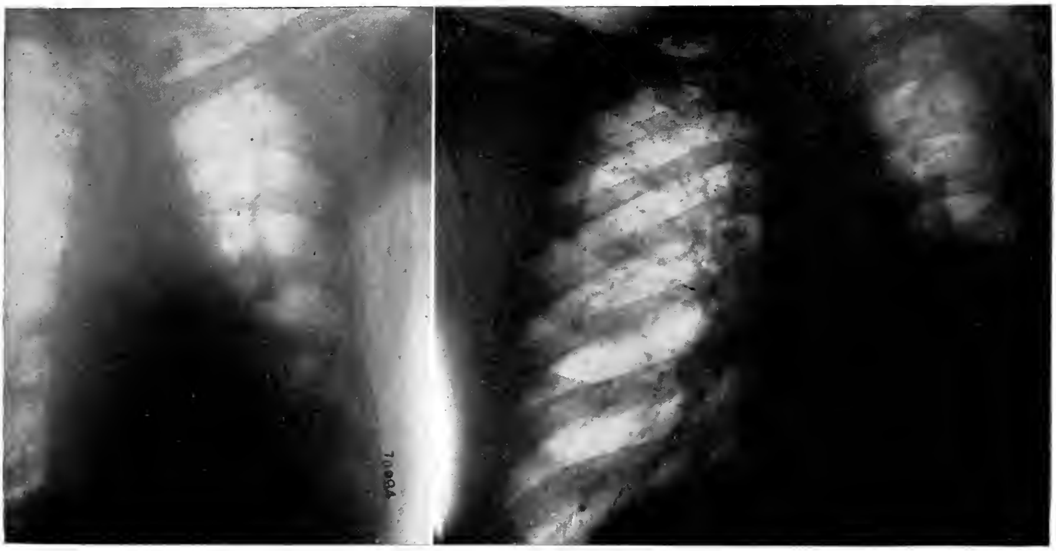
As illustrative of the relative tolerance of the bronchi to metallic foreign bodies, so strikingly in contrast to the almost immediate reaction which follows the entry of vegetable foreign bodies, because of the tendency of the latter to disintegration and migration (Bégin has called this class of foreign bodies "progressors") the following case is reported:



Figs. 1 and 2. Pl. A. No. 220543; Serial No. 70543, July, 1920. Coin (dime) in Left Bronchus. Destruction and Atelectasis of Left Upper Lobe, Fibrosis and Atelectasis of Left Lower Lobe.

M. G., aged forty-five, entered Bellevue Hospital because of hemoptysis. The following history was obtained: Fifteen years ago he was holding a dime in his mouth and someone slapped him on the back and he felt the coin go down. He thought he swallowed it. He coughed for about ten minutes after this, trying to get the foreign body up but without avail. He was not short of breath and went about his work as usual, though for six months following the accident he could feel something "moving up and down" in his chest. During this time he coughed but very slightly. From that time, however, until six months ago he has been practically free of symptoms, with the exception of a very slight cough. There was no shortness of breath, no purulent expectoration. Six months ago he coughed up a considerable quantity of bright red blood. After this he again felt the sensation of something "moving up and down" in his wind pipe for two weeks. During this time the coughing was very severe and he had considerable expectoration with it. The symptoms abated and he was practically well until two weeks ago, when severe hemorrhage brought him to the hospital. From the clinical signs the diagnosis of fluid at the base of the left lung, with fibrosis of the upper portion of the left lung, a possible cavity and a possible aneurysmal dilatation of the aorta was made. Sputum showed presence of fungus but no tubercular bacilli.

The radiographic examination shows an almost complete excavation and atelectasis of the upper lobe of the left lung, with fibrosis and atelectasis of the lower lobe. The heart and mediastinal contents were re-

tracted to the left. The trachea, however, was slightly deviated to the right. The opposite lung showed extensive compensatory emphysema. Between the seventh and eighth ribs, posteriorly, just to the left of the median line, was the shadow of a disc-like metallic body (the coin), its rounded edges somewhat roughened (due to calcarious deposit). The lateral view of the chest showed the coin located posteriorly in the main bronchus of the left lung, and lying in a plane parallel to the sagittal plane of the chest. The esophagus was normal.

That metallic foreign substances are tolerated in the bronchi without severe symptoms is well known in the literature. Such foreign bodies as nails (Collard), coins (Mitchel, Baldwin, Dupuytren), pins and pieces of bone have been found in the trachea and bronchi, where they had been for years without giving severe symptoms. Burch and Lake cite thirty-one cases in which foreign bodies were present in the trachea or bronchi in intervals of one year to sixty, in all of which recovery took place after expulsion or removal. In a case reported by Dupuytren a ten sol piece remained in the bronchus for ten years.

The pathogenesis of the lung lesion is usually the following: bronchitis, bronchopneumonia (peribronchial infiltration), multiple abscess formation, coalescence of the foci with the formation of a large cavity. With this there is fibrosis both of lung and pleura. These lesions were present in the case reported.

The foreign bodies remaining in the bronchi and trachea for a long time become covered with calcareous concretion. Several such cases in which foreign bodies were expelled after a long period, in calcareous form, have been collected by Aronssohn. He cites one case in which a cherry pit in the right bronchus was expelled a year after its inhalation, surrounded by a layer of phosphate of lime, one inch in thickness. (Hirsch, Foreign Bodies in the Alimentary and Respiratory Tracts, *Am. J. Surg.*, January and February, 1913.)

Hemoptysis appears to be a symptom present in the vast majority of such cases. Such recurrent hemorrhages may be the only symptoms for a long period. In many cases, sometimes in spite of a definite history, it is usually ascribed to tuberculosis.

It is difficult to understand how, in these days of abundant roentgen examinations, any foreign body in the respiratory tract can lie undiscovered for any length of time. The paucity of symptoms in a certain class of cases, of which the case reported is an example, may perhaps account for this. But nevertheless cases are being continually encountered in which, in spite of a characteristic history and distinct symptoms, the foreign body has been permitted to remain in the respiratory tract until irretrievable damage has been done to the lung and the removal of the foreign body, even by the skillful bronchoscopist, is no longer a simple matter.

The almost uncanny dexterity with which men like Chevalier Jackson remove the offending bodies from the inner and most submerged provinces of the lung makes one feel that the life of Pope Adrian IV, who died of a fly in his bronchus, would have been saved if Jackson had lived in Rome in the days of that august personality.

During the removal of the foreign body (a ten cent piece, partially encrusted) in the case reported, severe hemorrhages occurred, from which the patient died.

X-RAY FINDINGS IN THE CHRONIC GAS CASES* †

By HENRY C. PILLSBURY, M.D.

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THE close of the war and the return of our troops from France find scattered throughout the country many men who have been subjected to the action of irritant gas at some time during their service. These men will soon return to their civil status, and from time to time will appear at the *x*-ray clinics for the diagnosis of lung conditions. It is confidently expected that no man will be discharged, and later leave the care of the Public Health Service, who stands in need of any further medical treatment for the condition that was caused by his service; but these "gassed cases" will carry with them for a long time the scars caused by the irritant effect of the gas. Unless pathology of this condition is thoroughly understood, erroneous diagnoses may be made, and undue importance may be attached to the various thickenings of the bronchi seen.

Especially must the clinician be on his guard against the diagnosis of tuberculosis in these cases. It is not considered likely that any roentgenologist would make this mistake, as the appearance of the plate is entirely different in the two cases.

The gases that leave behind them a chronic change in the lungs are chlorine, chloropicrine, and especially phosgene. Contrary to the usually accepted opinion, mustard gas is practically without effect on the lungs. In this connection, care must be taken with the history. Nearly always the patient will state that he was gassed by mustard, when in point of fact he had no idea whatever with what gas he was affected. The several gases were used together to a certain extent. Further mustard causes such severe external burns that its action is most impressive. It is an easy name to remember, and in a great majority of cases soldiers will give the history of gassing by mustard quite confidently, although they may have actually inhaled phosgene.

The Research Division of the Chemical Warfare Service has done invaluable work on the pathology caused by the different gases. The description given below is taken almost entirely from their monographs. It is regretted that the masterly and scientific descriptions should be so garbled as has been inevitably the case, in the effort to present the condition as briefly as is consistent with reasonable clearness.

The pathology in the lungs caused by these gases is similar, but presents certain points of difference. Chlorine damages especially the upper respiratory tract, the trachea and the larger bronchi. This gas is a powerful irritant, and strikes that portion of the lung with which it first comes in contact. There is rapid and complete coagulation of the mucous surface; later, after recovery, the epithelium is restored, and the trachea returns to normal, except for the deposition of scar tissue. Rarely the injury may extend to the distal alveoli, causing desquamation of the alveolar epithelium and focal areas of necrosis.

Chloropicrine injures the epithelium of the trachea and larger bronchi, as does chlorine, but to a lesser degree. With this gas, the most notable effect is seen on the medium and smaller sized bronchi. When the bronchiolar wall has been seriously damaged, an active proliferation of fibroblasts occurs, and the bronchial cavity becomes filled with granulation tissue; the final result is an obliterative bronchiolitis, with its consequent atelectasis or localized emphysema. The same result may also occur as a consequence of occlusion of the smaller bronchi by in-

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†Thesis presented on application for membership in The American Roentgen Ray Society.

flammatory exudate, or by masses of necrotic cells. There is regeneration of the epithelium of the bronchi and alveoli, and organization of the necrotic bronchiolar wall, with scar formation. Focal atelectasis and emphysematous patches may remain.

Phosgene, the most important of all the gases used, in so far as the effect on the lungs is concerned, acts chiefly on the lining epithelium of the smaller bronchi and bronchioles. The upper respiratory air passages escape almost entirely. This gas as it is inhaled has no irritant properties. When, however, the gas reaches the moisture-laden smaller air passages, it is broken up, and HCl evolved. The lining epithelium is destroyed; later the epithelium regenerates, but there is a growth of granulation tissue in the walls of the finer bronchi which causes a thickening of its wall and a peribronchitis. In fact, the outstanding features of the later stages of this condition are the thickening of the walls of the bronchi, and the peri-bronchitis. In a certain number of cases this process goes further, and we find that the infiltration of the walls has extended to the point that the bronchus is entirely occluded. When this occurs, localized atelectasis and restricted areas of emphysema may be expected to be found.

Summarizing the action of the three most important gases, we find, therefore, that chlorine, the most irritant, affects the lining epithelium of the parts with which it first comes in contact—the trachea and larger bronchi. Chloropicrin, which must be broken up into a residue and HCl, only becomes effective after it has reached a part of the lung where moisture can be found—the medium sized and smaller bronchi. Here it causes the same lesions as chlorine. Phosgene is a little more stable than chloropicrin, and is only broken up into HCl and its residue in the smaller bronchioles and alveoli. It is here that it has its effect. It need not be supposed that these three gases are strictly limited in their action to the parts of the lung described; a massive dose or prolonged exposure of phosgene or chloropicrine will affect the larger bronchi as well as the finer ones.

The history is usually indefinite. As a rule these patients entirely recover their strength and their ability to do work. Occasionally, in the more severe cases, there may be shortness of breath on exertion. Nearly always they report to the roentgenologist for examination because of abnormal auscultatory signs picked up by the clinician when consulted for some intercurrent disease.

The x-ray plate will show changes closely resembling those found in pneumoconiosis. Adopting the classification used by Pancoast, Miller and Landis in their article published in The American Journal of Roentgenology, March, 1918, we find that these cases of gassing simulate the condition described by these authors as Group 1, the stage of irritation. As in the lungs irritated by the inhalation of dust, we find that the bronchial markings are unusually prominent. Reaching out from the hilus like a bush in the winter time the thickened stalks and twigs of the bronchi extend to the mid-portion of the lung, standing out clear and distinct, with no splotches of exudate to mar or confuse the picture. The bush is symmetrical; it is not confined to one lobe, or to the upper more than the lower portion. It reaches out from the hilus evenly, into all lobes, and is present on both sides. As a rule, the extension is more into the middle lobe on the right side, and into the lower portion of the upper lobe on the left. Because of the overlying heart shadow, the involvement on the right is more apparent than it is on the left. In some instances, added to the outermost twigs, are finer linear markings reaching to the periphery. In the more severe cases, there may be an area or two of localized atelectasis.

Should the gas be chlorine, or should the exposure to chloropicrine or phosgene be unduly prolonged, then the picture is varied by lesions of the trachea and largest bronchi. This condition is differentiated from the early cases of pneumoconiosis in two particulars. The hilus shadow may not be enlarged; its enlargement when present is caused by the chronic bronchitis that sometimes persists. In the second place, there are no small areas of increased density to give

the characteristic mottled appearance of dust inhalation.

The diagnosis from pulmonary tuberculosis is ordinarily not difficult. The distribution, the uniformity, and the absence of areas of consolidation, suffice to make the distinction clear. In certain instances, however, the presence of areas of atelectasis or emphysema, particularly when these occur in the upper lobes, may confuse the diagnosis considerably. Given the history of gassing, a consideration of the pathology that may ensue will assist in making the interpretation less difficult.

THE PRACTICAL APPLICATION OF THE SPHERE GAP TO ROENTGENOTHERAPY*

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CHICAGO, ILLINOIS

IN looking through the literature on roentgenotherapy one cannot help noticing the great variation in spark gap used by different workers in obtaining essentially the same results. It would seem, according to later writers, that such variations should produce results varying proportionally to the differences in gaps used and that, with the same gap, distance, milliamperage and time, essentially equal effects should be obtained, if Coolidge tubes be used. It is well known, however, that this does not occur in practice. What is an erythema dose with one machine is not necessarily the same with another. If we use the same voltage, distance, intensity and time we would expect to get approximately the same effects with transformers of similar type, but the difficulties of working out dosage when changing from one machine to another or when trying to duplicate another worker's results with a given dosage are very real.

Why is one not able, with accurate meters and the Coolidge tube, to obtain as uniform results from a given dosage as with the alkaloidal drugs given hypodermatically? There one expects uniform results in the same type of patient whether a record or a Luer syringe is used provided the same quantity and quality of the drug is used.

In measuring dosage of the roentgen ray we have the same two factors, quantity (represented by milliamperage, time and distance) and quality, depending upon voltage applied to the tube terminals. Wave shape, number of cycles, etc., are not taken into consideration, as there is little evidence at present showing their importance in roentgenotherapy. There is no question but that we get sufficiently accurate quantitative measurements, with the milliammeter, a clock and a tape measure; but what about the qualitative?

The usual method of measuring voltage is in terms of spark-gap between blunt points, sometimes in kilovolts as read on a meter in the primary circuit; and as these seemed much like using an elastic tape measure to measure distance the following investigation was undertaken to determine how great the inaccuracy of the orthodox method of measuring voltage (penetration) was. Before taking up the results of actual measurements made at the tube the drawbacks of the needle gap and voltmeter on primary will be briefly taken up.

In measuring voltage with a needle gap considerable inconsistency has been found by investigators, and this seems especially true of European workers. Quoting J. Lustgarten [4]: "Those that have worked with the gap specified (standard A. I. E. E. needle gap) know that it is difficult to check the American values and even to repeat their own re-

*Read at the Midwinter Meeting, Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 22, 1921.

sults on successive days. One reason for this lies in the effects on the brush discharge of humidity, pressure and temperature, position of the needles with respect to the supports and neighboring objects and the local conditions in the circuit. The brush discharge in the case of needle points always precedes the spark (except at very small distances). A screening by metallic discs at the back of the needles will not prevent humidity, pressure and temperature destroying the standard gap."

To realize this inconsistency one has only to turn to the tables derived by different investigators showing the relation between distance of separation and the breakdown voltage. For example:

U. S. Army *X*-Ray Manual:

40 KV	Gap 3 inches
50 KV	Gap 4 inches

etc., the ration being 10 KV per inch plus 10.

Peek, *Dielectric Phenomena in High Voltage Engineering*, first edition:

40 KV	Gap 2 13/32 inches
50 KV	Gap 3 3/17 inches

etc.

Raper, *Dental Radiography*, first edition: 10 KV per inch.

Knox, third edition, p. 19. Type of gap not stated:

110 KV	4 inches
150 KV	8 inches
190 KV	12 inches
230 KV	16 inches.

This table obviously refers to a sphere gap and shows the difficulty one would have in attempting to correlate his work with the English standards.

The needle gap is also cumbersome if one attempts to use it accurately. Section 245 A. I. E. E. Standardization Rules specifies the following:

"The sparking points should consist of new sewing needles supported axially at the ends of linear conductors which are at least twice the length of the gap. There should be no extraneous body near the gap within a radius of twice its length."

How many roentgen plants are equipped with a gap built according to the above? The average gap as commonly used brings in many sources of error not found in the standard. Peek [2] makes the following statement:

"The needle gap is unreliable at high voltages because, due to the brush discharge and broken-down air that precedes the spark-over, variations are caused by humidity, oscillations, and frequency.

"The needle gap is also inconvenient because needles must be replaced after each discharge; the spacing becomes very large at high voltages, and the calibration varies somewhat with the sharpness of the needle."

"A higher voltage is required to spark over a given needle gap when the humidity is high than when it is low.

"All spark gap curves of whatever form of gap must be corrected for air density—that is, altitude and temperature. For low voltages the spark-over of the needle gap decreases approximately as the air density. At higher voltages the effect becomes more erratic, probably due to humidity."

In using a KV meter on the primary even greater sources of error may be encountered. To quote Chubb and Fortescue [3]:

"The most usual method of measuring the high tension voltage is to measure the primary potential and multiply by the ratio of the transformer. Voltages obtained by this method are generally very much in error due to the distributed capacity in the high tension winding of the transformer, harmonic distortion of the applied voltage wave and the capacity of the terminal bushings and the apparatus to which the high voltage winding is connected. The effective low tension voltage is usually indicated so that there is no measure of the maximum unless a pure sine wave of voltage is applied, there are no appreciable distortions due to the harmonic components of the exciting currents and the capacity regulation can be corrected."

If the usual methods of measuring voltage (penetration) are so faulty, what is the remedy? Engineers have been using a sphere gap for a number of years to measure high voltages and it is well known to be the most

ERRATA

The following corrections were received from Dr. Ullmann after the article had been printed:

p. 197: *Ingenieurmessen* should be *Ingenieurwesen*
p. 198: first column: MacKee formula should read:

$$\frac{\text{gap} \times \text{time} \times \text{milliamperes}}{\text{distance}^2} = 36/64$$

p. 198: second column, table:
In caption, V^1 and V^2 should be U^1 and U^2
Third line, last column, —110 should be —11.

accurate practical method. It is more consistent, the breakdown voltage being affected only to a negligible degree by widely varying conditions of atmospheric pressure, humidity, proximity of neighboring bodies, etc.; more convenient because the terminals do not have to be renewed and it requires less space.[4] Under certain conditions the breakdown of the air gap between equal spheres is very constant and the sphere gap that has already been suggested as a standard for high voltage measurements has been found to be more reliable than the usual methods of test.[3] The results of many tests show the breakdown voltage to be independent of wave shape and frequency when expressed in terms of the maximum value of the voltage wave.[3] Farnsworth [5] quotes Weicher's *Mitteilungen über Forschungsarbeiten auf dem Gebiete der Ingenieurmessen,* Berlin, 1911:

"For sphere gap used over a separation not greater than the diameter of the spheres the influence of the factors of humidity, temperature, pressure, frequency and electrical capacity on the sparking voltage is as follows:

"Humidity—No effect.

"Temperature—Sparking voltage is inversely proportional to the absolute temperature.

"Pressure—Sparking voltage is directly proportional to the barometric pressure.

"Frequency—Within commercial range—20 to 75 cycles—frequency has no effect on the sparking voltage.

"Electrical capacity—No influence."

If the sphere gap is so accurate it should prove any variation of voltage measurements made in estimating x-ray dosage. In order to test this the following procedure was carried out in a number of hospitals and private laboratories at Chicago.

The roentgenologist was requested to set his machine for a definite voltage and milliamperage such as he used in therapy and then the voltage was measured at the tube terminals with a sphere gap. Only Coolidge tubes were tested. The findings are as follows:

MACHINE A

Meter reading KV	*Milli-amperes*	*Rheo Button*	*Auto Button*	*Gap in inches*	*S.G. KV*
30	25	out	31	2⅛	34.5
35	25	"	35	2⅞	39
40	25	"	40	3½	49
45	25	"	45	4¼	56
50	25	"	50	4⅞	62
55	25	"	55	5¾	71
60	25	"	59	6⅜	77
65	25	"	64	7¼	81
70	25	"	69	7⅝	88
75	25	"	74	8	93
80	25	"	79	8⅞	98
76	5	1	113	5½	60
85	5	2	102	8⅛	77
85	5	10	88	8⅝	89

MACHINE B

Meter reading KV	*Milli-amperes*	*Rheo Button*	*Auto Button*	*Gap in inches*	*S.G. KV*
35	25	out	1	3	46
46	25	"	2	4⅝	56
57½	25	"	3	5½	70
47	5	"	2	5	58
58	5	17	3	6	70
62½	5	9	4	6	65
63	2	7	4	6	62
70	5	7	5	6	62
73	5	5	6	6	65
76	5	10	5	7½	73
78	5	12	5	8	80

MACHINE C
No auto transformer

Gap in inches	*Milliamperes*	*S.G. KV*
	High Button	
4½	27	52
5	27	60
5	5	51
6	5	60
7	5	68
8	5	74
	Low Button	
6	5	60
7	5	70
8	5	80
9	5	90

MACHINE D
No auto

Gap in inches	*Milliamperes*	*S.G. KV*
6	3	54
6	5	55
8	3	70
8	5	73
9	2	75
9	6	82

MACHINE E
No auto

Gap in inches	*Milliamperes*	*S. G. KV*
7½ to 8	5	75

MACHINE F
Auto transformer

Gap in inches	*Milliamperes*	*S. G. KV*
6	2	65
6	6	65
8½	5	82

It is easily seen from an examination of the above that there is considerable variation of voltage where one would expect uniformity from the results of his spark gap readings.

In order to get these findings in terms of dosage the following table was made. Column C is the gap between points in inches as measured by the operator. KV is the actual voltage at the tube as measured by the sphere gap. U^1 is an arbitrary unit based on the MacKee formula—

$$\frac{\text{distance}^2}{\text{gap} \times \text{time} \times \text{milliamperes}} = 36/64 =$$

one unit, and represents what the operator thought he was using. U^2 is derived in the same way, using 70 KV instead of a 6 inch gap, and represents what he actually got. 70 KV was taken because it more nearly represents the actual voltage at the tube when the point gap registers 6 inches.

Per cent plus or minus represents the difference between what the operator thought he was using and what was actually used.

	C	*KV*	*U1*	*U2*	*Per cent*
Machine A	5¾	71	.96	1.01	+4
Machine B, setting 1	6	65	1.00	.93	—7
Machine B, setting 2	6	70	1.00	1.00	100
Machine C	6	60	1.00	.85	—15
Machine D	6	55	1.00	.80	—20
Machine F	6	65	1.00	.93	— 7

From the above table it is readily seen that if an operator using machine D should change to A and give what he had been in the habit of using for an erythema dose he would actually give 30% more. Conversely if operator of A transferred to D and gave what he supposed would be an erythema dose he would actually be using only 77% of the amount.

	C	*KV*	*V1*	*V2*	*Per cent*
Machine A	8	93	1.00	1.03	+3
Machine B	8	80	1.00	.89	—11
Machine C, setting 1	8	80	1.00	.89	—110
Machine C, setting 2	8	74	1.00	.82	—18
Machine D, setting 1	8	73	1.00	.81	—19
Machine D, setting 2	8	70	1.00	.78	—22
Machine E	8	75	1.00	.83	—17

In this table 90 KV was taken as representing 8 inches of back-up and an 8 inch gap the unit for deep therapy.

From the above it can be seen that if what would be an erythema dose on machine D, setting 2, was given with machine A, the patient would receive 1.32 times the dose, while if the readings used on A in producing an erythema were used on D only 76 per cent of the dose would be received.

If dosage were based on kilovolts instead of spark-gap and machines were calibrated so that one knew that certain settings would produce a definite voltage one should be able to change from one machine to another and expect to get the same results without previously testing out the effects on a patient. Also, a roentgenologist could publish the results obtained from a certain dosage with the knowledge that those who attempted to duplicate his results would at least use the same quantity and quality of rays.

There is nothing difficult in using a sphere gap. In fact it is easier as there is no corona and no preliminary sparking. It either fires or it does not, and the difference of a small fraction of a millimeter determines the sparking point. It is easily calibrated to read directly in kilovolts, and the machine once calibrated for the settings in common use, it will only be necessary to recalibrate at long

intervals or when tubes are changed or different control buttons used.

CONCLUSIONS

The present method of estimating quality or penetration by parallel spark-gap between blunt points is exceedingly and unnecessarily inaccurate and is equivalent to measuring tube distance with a rubber band for a tape measure.

The use of the sphere gap in estimating voltage between tube terminals is accurate enough for all practical purposes and is actually easier to use than blunt points due to absence of brush discharge.

If the number of kilovolts used were stated instead of the amount of spark-gap back-up in reporting dosage the results could be duplicated by other workers as easily as in giving drugs hypodermatically and would be an advance in dosage standardization.

I wish to thank Dr. W. D. Coolidge for his advice and assistance in this work.

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4. Farnsworth and Fortescue. *A. I. E. E.,* Feb, 1913.
5. Farnsworth. *A. I. E. E.,* Nov., 1913, p. 2089.

THE VALUE OF PROPHYLACTIC X-RAY TREATMENTS*

By SAMUEL STERN, M.D.

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NEW YORK CITY

It is rather difficult to determine the value of treatments intended to prevent the recurrence of ailments presumably cured. Nevertheless there are certain indications that justify our drawing definite conclusions as to the results accomplished by the aid of these treatments.

If we know through long experience that in a series of similar cases we may expect a certain number of recurrences, and then find that as the result of treatments carried out this number has been diminished, we are justified in presuming that our treatments have been of some value.

Conclusions reached upon these premises are always open to the objection that perhaps the series of cases, while apparently similar, have in reality not been quite the same. Every surgeon has his own statistics as to his percentage of recurrences in malignant cases operated by him, and they vary in a large degree. Another, and in my opinion, more convincing method of reaching conclusions as to the value of prophylactic treatments, is to take selected individual cases of a character which in the opinion of the operating surgeon would unquestionably result in the recurrence of the lesion operated for. If in these cases we succeed through our treatments in preventing this expected recurrence, we are in a much better position to show concrete proof of the value of the treatments carried out.

The object of this paper is to describe a number of cases which without some interference would have unquestionably resulted in a recurrence, and to show that by a series of prophylactic *x*-ray treatments this expected recurrence has never materialized.

Case I. Mrs. F. S., sixty-two years old, referred to me by Dr. H. Herman in October, 1911, with a diagnosis of papilloma of the tongue.

Patient had a small growth, about the size of a lima bean, on the edge of the right side, at about the junction of the second and last third of the tongue. There was something suspicious about the appearance of the lesion, and I reported to Dr. Herman that in my

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14-17, 1920.

opinion we were dealing with an epithelioma and not a papilloma. We decided to remove a small section for microscopical examination, this to be followed by immediate fulguration.

The examination was made by Dr. Harlow Brooks and the lesion was found to be an epithelioma. The fulguration (not dessication) was followed by periodical prophylactic *x*-ray treatments, with the result that up to date (nine years later) there is not the slightest sign of recurrence and the patient is apparently perfectly well.

The patient was treated with a unipolar *x*-ray tube which I devised in 1904.[1] This tube enables us to apply the *x*-ray in immediate contact with the part to be treated. While the output of this tube is rather small, the fact that it can be put in direct contact with the tissues makes it possible to administer considerable *x*-ray at each treatment.

Case II. Miss A. B., forty-seven years old, referred to me by Dr. D. D. Goldstein in November, 1913. Mother died of cancer of breast in 1908. Patient first called on Dr. Goldstein in November, 1913. He found that she had a fair-sized tumor in the right breast, with axillary involvement. He advised immediate operation, but patient waited about two weeks, at the end of which time there was a very marked increase in the size of the tumor.

On operation there was found to be a large tumor of a very diffuse type, with marked involvement of the axillary glands. The sheets of all the blood vessels were involved and they all had to be stripped. The microscopical examination showed the tumor to be a medullary carcinoma of a very malignant type.

The patient followed up her *x*-ray treatments in a very reluctant way. She felt that she was wasting her time and money, so I had to be satisfied with treating the operated side where recurrence seemed most imminent. I succeeded in holding her for about one year, after which time she disappeared. I next saw her in July, 1919 (about six years after her treatment). The right side, where she had the prophylactic treatments, has remained entirely free; but the left side became involved and was operated on by Dr. D. A. Moschkowitz, who found a very malignant diffuse type of carcinoma with marked axillary involvement. I began to treat this side and up to date she has remained free of any recurrence.

I consider this a most instructive case. The original side (right) which was almost entirely involved in a very malignant type of extremely diffuse carcinoma, has remained free up to date (six years) following the prophylactic *x*-ray treatment, while the opposite side, which did not receive any treatments, was the site of recurrence.

Case III. Mr. L. M. E., sixty years old, referred to me by Dr. Edwin Beer in January, 1916, for prophylactic *x*-ray treatments following a nephrectomy for hypernephroma of the left kidney. I will give Dr. Beer's description of this case, as published by him in the *International Journal of Surgery*, December, 1919:

"Mr. E., aged sixty odd years, was operated by the lumbar route for an acute hematuria from the left kidney. The diagnosis of hypernephroma of the left kidney had been made and the tumor mass could be felt in the left lumbar region. If ever a patient looked absolutely hopeless to the surgeon this patient surely did. The pelvis of the left kidney was filled with the tumor mass, which extended through the parenchyma and then had grown through the capsule of the kidney into the perinephritic fat, where a tumor as large as a good-sized fist was growing. The kidney was removed through the lumbar route, but naturally, with the tumor extending from the cortex, it seemed at the time that it would be impossible to deliver the kidney and tumor without spilling the tumor cells." (As a matter of fact, in a letter written to me by Dr. Beer on July 6, 1920, he states that he thought he must have spilled some of the viable tumor tissue.) "After removal of the kidney, all perinephritic fat was carefully excised, and the patient was

[1] *Medical Record*, Sept. 24, 1904.

subjected to intensive x-ray therapy. To-night (four years after operation) the patient presents himself in perfect health apparently. Last spring I made a complete examination and found no evidence of any disease."

Unfortunately I heard recently that this patient had passed away, suffering from a brain lesion, perhaps due to some metastasis in the brain. This I could not make sure of.

Case IV. Mr. L., forty-five years of age, referred to me by Dr. A. Hyman, in August, 1916, for prophylactic treatment, following an operation for carcinoma of the testicle. I will quote from Dr. Hyman's letter to me (June 7, 1920) in reference to the case:

"Mr. L. was operated on July 19, 1916. In incising through the skin of the scrotum, a large amount of pus with necrotic material was evacuated; all the scrotal layers were edematous. A large tumor of the testicle was found, which had broken through the tunica and had infiltrated the scrotum. The tumor was necrotic in areas and the size of a fist. A typical orchidectomy was done, removing the cord up to the external ring. Pathological report: Carcinoma. In view of the fact that the growth had ruptured through the tunica and had become attached to and had infiltrated the scrotal tissues, I considered the prognosis very bad, and advised either x-ray or radium treatment. It is now almost four years since his operation and x-ray therapy; the patient, when last examined three months ago, was in excellent condition, with no evidences of local recurrence or metastases. A statement from his family physician, received a few days ago, confirms this report."

This patient, when first seen by me, had a great deal of induration in the operated region—so much so that I even feared at the time that a local recurrence was imminent. He also had considerable induration in the inguinal region, and Dr. Hyman felt quite confident that unless some method was found to prevent it a local recurrence was unavoidable.

Case V. Mrs. L., fifty-three years old, operated on April 14, 1916, by Dr. Cragin for double cystic ovaries. On section, both cysts showed a cystic and a firmer solid new growth, with part of the capsule invaded by tumor tissue. At the time of the operation, one of the cysts ruptured and the contents spilled into the peritoneum. On microscopical examination, the solid portion showed nests of large cells and a well-marked alveolar arrangement. A diagnosis of adeno-carcinoma was made. This condition was unsuspected before and even during the operation, so the operation was not as thorough and radical as it would have been had the condition been recognized. As part of the capsule was involved and the contents of the cyst spilled into the peritoneum, recurrence was much to be feared.

Prophylactic x-ray treatments were carried out for about a year and a half, and there has been no sign of recurrence up to date (four and a half years after operation).

About two months ago this patient was operated upon for a gangrenous appendix. At this time the surgeon carefully explored the pelvic organs and found the uterus freely movable, without the slightest sign of recurrence. She made an uneventful recovery.

I have treated a number of other cases that I think would also clearly demonstrate the value of prophylactic x-ray treatments, but my time does not permit me to go into detail about these, as I would like to say a few words in regard to the technique and dosage that I have been using.

Prophylactic x-ray treatments, to be of value, must be efficient and must be persisted in for a considerable period. If possible, they should be kept up for about three years after the operation. This is very difficult. Most of the patients will be tired of the treatments long before this period expires, and it can only be carried out if you have an intelligent patient to deal with and if there is a proper cooperation with the operating surgeon and the family physician.

I try to give the treatments in the following routine where I can: First treatment, as shortly after operation as possible; the next

two treatments, at about three weeks' intervals; the next two at four weeks' intervals. This is followed by treatment at six weeks' intervals for the balance of the first year. The second year treatments are given at two months' intervals, and the third year, at three months' intervals.

Of course, the treatments given the first year are the most important, and in the majority of cases you will find considerable difficulty in holding your patients longer than this; but whenever possible, try to get them to persist the full time.

In treating them, be sure to take in as large an area as possible, with special attention to the glandular region surrounding the involved area, also the parts where experience has taught us to expect most probably a metastasis. For instance, in carcinoma of the breast the opposite side should get some treatments—not necessarily as many as the involved side; and, in addition, I think it is advisable to treat the lumbar spine, where many of the metastases will appear.

I think the time will come when these patients will be given a complete *x*-ray bath—in fact, I believe it is quite feasible now. Instead of using small fields, we can have our tube at a distance of about 16 or even 20 inches, take in large areas at a time, and expose the entire body from all directions. I have not tried this as yet, but I am seriously thinking of doing so.

The cases reported above were all treated with the small field cross-fire method.

Dosage.—Try never to produce an erythema in these cases. It unnecessarily frightens the patients, discourages them from persisting with the treatment, and leads to telangiectases and other unpleasant skin conditions. I never use more than three-fourths of my maximum dose at any exposure. I find it more satisfactory to speak of maximum dose, and fractions thereof, than of a definite number of X. Your maximum dose never varies, while the measurements in figures of X generally do.

In standardizing my apparatus I find that the following figures represent my epilating dose—that is, a dose which will produce epilation without an erythema. I have taken this as a standard maximum dose, above which I never go.

Apparatus.—Forty centimeter air-cooled coil, with gas and mercury jet interruptor. Coolidge tube.

Distance	*Spark-gap*	*Ma.*	*Time*	*Filter*
8 inches	9 inches	5	10	4 mm. aluminum and several layers of photographic paper.

In giving these treatments, I use the above formula, except that the time is seven and a half minutes instead of ten. The tendency has been recently to abandon the aluminum filters for those made of copper and zinc. These metals have the advantage of increasing the *x*-ray penetration, but have the disadvantage of requiring much longer exposures. Where you have a large area to cover, this time element becomes of great importance, especially in patients who do not stand the treatments well and who are subject to various kinds of constitutional disturbances. Still, I think that probably we shall have to make the best of this disadvantage. If there is any additional therapeutic value in higher penetrating rays, these patients ought to get the benefit of it.

In closing, I wish to say that I firmly believe sufficient evidence has been gathered by this time to justify our belief in the value of prophylactic *x*-ray treatments. Every operation for malignancy should be followed up with these treatments, and these patients given the additional chance to escape recurrence.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M. D., *Editor* · Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

SIXTH ANNUAL MEETING THE AMERICAN RADIUM SOCIETY

BOSTON, JUNE 6 AND 7, 1921. HEADQUARTERS, HOTEL BRUNSWICK

WASHINGTON MEETING

PRELIMINARY ANNOUNCEMENTS

Plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. Réné Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it necessary to attend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

A. C. Christie.

The Twenty-second Annual Meeting of The American Roentgen Ray Society will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of The American Roentgen Ray Society. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person,	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On

these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

Annual Meeting Western Section

The officers of the Western Section of The American Roentgen Ray Society are making plans for their second annual meeting. They have selected Portland, Oregon, as the place of meeting, and the time has been set for May 27th and 28th. This time will permit of a continuous trip for the western men who desire also to attend the A. M. A. meeting in Boston.

The Pacific Coast Roentgen Ray Society will meet at the same time and place, the two organizations being the guests of the Portland Roentgen Club, a very active organization of specialists.

The Secretary of the Western Section would welcome a visitor or two from the East with papers or demonstrations, and can assure them of a very enjoyable meeting. Address Dr. Warner Watkins, Box 1328, Phoenix, Arizona.

NEW COMMITTEES

Safety, and Laws and Public Policy

At the last meeting of the American Roentgen Ray Society two important committees were created, a Committee on Safety and a Committee on Laws and Public Policy.

The Committee on Safety is charged with the investigation of all matters pertaining to the dangers incurred in the practice of roentgenology, and recommending measures to increase its safety. This will necessitate an extensive investigation by the committee in order that it may collect data covering the experience of as many men as possible. It is hoped that all members of the Society and readers of the Journal will cooperate with the Committee both by sending to it, voluntarily, any information that may be of value, and by answering any questions that may be sent to them with regard to accidents and injuries, both electrical and x-ray, that have occurred in their practice.

The Committee's recommendations with regard to the practical value of safety devices, as well as those for the elimination or lessening of the dangers pertaining to the practice of roentgenology, will undoubtedly be of great value to roentgenologists.

The Safety Committee consists of Prof. J. S. Shearer, Chairman, Cornell University, Ithaca, N. Y., Dr. P. M. Hickey, and Dr. W. D. Coolidge.

The Committee on Laws and Public Policy was authorized by the following resolution which states its purpose:

"During the coming year there shall be appointed by the President at his convenience a committee of three to be known as the Standing Committee on Laws and Public Policy: that it shall be the duty of this Committee on Laws and Public Policy to keep the Society informed as to changes in laws and legal decisions; to cooperate with similar committees from other medical societies and public welfare associations, generally, to the end that this Society shall be found in a proper attitude toward all matters of legislative and public policy which may be found to involve the welfare of the Society or properly to demand the Society's cooperation."

This committee consists of Dr. E. H. Skinner, Chairman, Rialto Building, Kansas City, Mo., Dr. Charles F. Bowen, and Dr. E. A. Merritt.

Any member of the Society who has any matter which he wishes to bring to the attention of this committee should communicate with the Chairman.

A. C. Christie.

SIXTH ANNUAL MEETING THE AMERICAN RADIUM SOCIETY

Preliminary Program

The Sixth Annual Meeting of The American Radium Society will be held at Boston, June 6 and 7. The place of meeting for scientific work will be the Harvard Medical School, the headquarters the Hotel Brunswick. Following is the preliminary program:

Monday, June 6th, 1921

Morning Session

A. Executive Session.
B. Scientific Session.

Treatment of Primary Carcinoma of the Vagina with Radium. Leda J. Stacy, M.D., Rochester, Minn.

Treatment of Uterine Cancer by Radium. Harold Bailey, M.D., Rochester, Minn.

Histologic Changes Occurring in Carcinoma of the Cervix following Radiation, with Special Reference to the Factor of Distance. Charles C. Norris, M.D., and Norman S. Rothschild, M.D., Philadelphia. (By invitation.)

Radium in the Treatment of Carcinoma of the Breast as an Adjunct to Surgery. Ben R. Kirkendall, M.D., Columbus, Ohio.

Radium Combined with X-Ray Treatment in Carcinoma of the Breast. George E. Pfahler, M.D., Philadelphia.

Treatment of Glandular Enlargements with Radium. Russell H. Boggs, M.D., Pittsburgh.

Afternoon Session

A Comparison of Radiation Dosages Attainable by Use of Radium on and without Tumors. Charles H. Viol, Ph.D., Pittsburgh.

Dosage in Radium Therapy. Gioacchino Failla, E.E., New York.

A Comparison of X-Rays with Gamma Rays. William Duane, Ph.D., Boston. (By invitation.)

Hyperthyroidism—Classification — Basal Metabolism in Diagnosis—Renal and Blood Findings—Treatment by Radium. R. E. Loucks, M.D., Detroit, Mich.

Action of Radium on the Blood and Blood-Forming Organs. Isaac Levin, M.D., New York.

Experiences in the Treatment of Nasopharyngeal New Growths. Curtis F. Burnham, M.D., Baltimore.

Treatment of Multiple Papilloma of the Larynx in Children. Gordon B. New, M.D., Rochester, Minn.

C. Short Executive Session.

Monday Evening

Annual Dinner.
President's Address. (Lantern slides.)

Tuesday, June 7th, 1921

Morning Session

A. Short Executive Session.
B. Scientific Session.

Radium in Dermatology. Frank E. Simpson, M.D., Chicago.

Dosage in Superficial Lesions. William S. Newcomet, M.D., Philadelphia.

Treatment of Carcinoma of the Rectum. Douglas Quick, M.D., New York.

Treatment of Prostatic and Bladder Carcinoma. Hugh H. Young, M.D., Baltimore.

Treatment of Malignant Disease of the Bladder. Benjamin Barringer, M.D., New York. (By invitation.)

Treatment of Brain Tumors by Radiation. Henry K. Pancoast, M.D., Philadelphia.

Tuesday Afternoon

Clinic at the Huntington Memorial Hospital, by invitation and under the direction of Dr. Robert Greenough, Director of the Hospital.

CANADIAN RADIOLOGICAL SOCIETY

Notice of Change of Meeting Place

The Annual Convention of the Canadian Radiological Society will be held this year in conjunction with the Ontario Radiological Society at Niagara Falls, Ontario, May 31 to June 4, inclusive. Members of the C. R. S. will please take notice of this change.

An invitation is extended to all members of the profession to be present, as the program to be presented will well justify the time spent.

L. K. Poyntz, Secretary-Treasurer.

The Third Congress of the Italian Society of Medical Radiology

The Third National Congress of Radiology took place in the Institute of Electrotherapeutics and Radiology in Rome, October 28 to 30, 1920. It was well attended by radiologists from all parts of Italy. The exhibits of radiological apparatus were large and of great interest.

The opening speech at the meeting was delivered by Prof. Ghilarducci, in which he very ably demonstrated the progress made by Italian radiology both from a scientific and industrial standpoint, and showed that they have been able to maintain a place equal in importance to that of other countries.

Prof. Bertolotti of Turin also delivered an interesting lecture on radio-activity in biology and chemistry.

Prof. Perussia (Milan) discussed the radiological researches of the heart and large vessels, extensively illustrated with clinical and radiological records of personal study.

Prof. Ponzio (Turin) then discussed fully the most recent physical and biological discoveries of radio-therapeutics and the practical results. His statements were strengthened by a large personal experience in the actual state of the therapeutics of cancer. This subject was discussed at length by the leading clinicians.

The program also included numerous other talks of most appealing interest showing fully the activity and scientific value of Italian radiology.

BOOK REVIEWS

THE RADIOGRAPHY OF THE CHEST, VOL. I. —PULMONARY TUBERCULOSIS. By Walker Overend, M.A., M.D. (Oxon) B.Sc. (Lond.) Pages 120; 108 Illus. Price $5.00. C. V. Mosby Company, St. Louis, 1920.

This is a book of moderate size containing ninety-nine radiograms and nine diagrams. The first chapter deals briefly with technique and the radiographic appearance of the normal chest. The author then discusses the classification of lesions and gives his own, which is a most rational one based on the clinical course and the radiographic findings.

The author, who is evidently a clinician as well as a radiographer, gives a brief digest of the history, physical examination, clinical diagnosis, and in some instances, the postmortem findings with each radiogram. The arrangement of text and illustrations is not altogether good, for in many instances the notes and radiograms of the same case are several pages apart, making it inconvenient to consult the radiogram while reading the interpretation of the same.

The illustrations are generally good, but in some cases the entire pulmonary area is not shown.

In the last chapter there is a brief discussion of various topics, such as the relative value of clinical and radiographic examination; incipient tuberculosis; tuberculosis in the great war; the heart in pulmonary tuberculosis, etc.

While not a profound exposition of the subject, this work of a combined clinician and radiographer contains material which should be of interest to both the internist and the radiographer.

JOHN G. WILLIAMS

TRANSLATIONS & ABSTRACTS

Greenough, Robert B., Boston. The Treatment of Tumors by X-Rays and Radium. (Read before the Fifth Congress of the International Society of Surgery, Paris, July 19 to 23, 1920.)

After speaking of the limited knowledge concerning the biological action of radium, the writer discusses the results of radiation of living tissue, which may be enumerated as follows: "(1) Living tissue may be destroyed *en masse;* (2) Growth may be temporarily inhibited; (3) The rapidity of growth may be stimulated; (4) The manner of growth may be modified."

While massive destruction of a complex tissue demands a dose of radiation sufficient to kill the cells of the different types of the area involved, the effects of stimulation, inhibition and modification of growth may be exerted upon individual cells and individual types of cells in the tissue area exposed to radiation, depending upon the dosage, the susceptibility of the cells to radiation, and doubtless upon other factors of which we have insufficient knowledge at present. In the treatment of non-malignant disease and for palliative (non-curative) treatment of cancer, all of the cells exposed need not be destroyed. But to cure cancer by radiation, the exposure must be shown to be 100 per cent efficient in destroying the disease, or recurrence is to be expected.

The massive destructive effect of the lethal dose of radiation is used in the non-metastasizing carcinoma of the skin in both the squamous and basal-celled varieties. It is also used in some of the metastasizing forms of cancer where the removal is impossible. Here the insertion method by the use of the bare tubes of emanation or of the needles holding radium salts or emanation at their tips, has proved effective in producing massive destruction. This method has been employed safely near the surface of the body where normal suppurative processes and their discharges may take place without the risk of deep and dangerous infection. Burying tubes of emanation in deeply situated tumors has proven unsatisfactory, either because the dosage has been too small to be effective or a degenerative process has resulted with secondary infection that made surface drainage necessary. For the treatment of certain malignant tumors on the surface of the body where operative removal is impossible, or in combination with operation, when the operative procedure alone was insufficient, the insertion of tubes of emanation with the resulting massive destruction, finds a field of great usefulness.

As the absorbed rays rather than the penetrating rays produce the greatest effects upon living tissues, it is probable that the beta rays are the most concerned in the production of massive destruction with the radium. For this reason massive destruction is produced only in close proximity to the source of radiation.

The phenomenon of temporary inhibition is shown by the fact that cells exposed to radiation for a certain time remain quiescent for a considerable period, only to awake to active and continued growth after the radium effects have passed away. The time before activity begins again is variable, in some cases several years.

That small doses of radiation produce a stimulant effect upon growth is generally conceded. It is impossible that one dose of radiation should contribute a constituent of growth that was previously lacking as would be the case if a plant or an animal were supplied with a greater quantity of light, heat or moisture. The primary inhibition of growth followed by the later increased rapidity of cell division would appear to justify the assumption that some damage was done by the radiation and as a result the normal processes in response to injury were excited.

In addition to the effect on the tumor, there is an effect seen in the normal tissue surrounding the diseased area. The earliest observable histological changes after radiation are a new growth of the cell elements in the blood vessels and connective tissue. It is impossible to state how much is due to radiation and how much to the natural processes or inflammation and repair excited by the damaged tumor tissue. There is, however, a marked new growth of connective tissue before any recognizable change in the epithelial cells is seen.

The modification of growth resulting from

the radiation of living tissue depends upon the tissue investigated to a great extent. Normal tissues may be made abnormal, and developing embryonic cells may be made to develop in an abnormal manner. This ability of radiation is shown in the clinic in its application to the relief of benign skin lesions such as papillomas and keratoses. In these the destructive effects are not needed or desired. After a mild reaction the deeper cells which were formerly growing in an abnormal manner begin to grow more normal. The abnormal cells are cast off and the lesion heals without a scar. While this action is of greatest value in the treatment of non-malignant lesions, it can be counted upon but little in the attempt to eradicate malignant disease. No modification of growth of cancer cells short of death and destruction of every cell is sufficient to cure the patient of cancer.

The so-called "selective action" of radium upon tumor tissue is next considered. Some benign lesions such as papillomas and keratoses, which yield to the "modifying" effects of radium without the destructive effect, are of the class of so-called "precancerous" lesions, but this does not permit us to presuppose a similar reaction when dealing with cancer tissue.

Different tissues show a variation in sensitiveness to radiation. Lymph-adenoid tissues and those of the ovary and testicle are especially sensitive. Certain tumors of lymph-adenoid tissue, such as malignant lymphoma (Hodgkin's disease) and lympho-sarcoma appear to exhibit a definite and positive sensitiveness, in that when they are first subjected to deep radiation, the tumor masses shrink and occasionally disappear, without undue damage to the normal tissues overlying. But it has been the experience of the writer, that the changes are temporary, and although a recurrence of the tumor masses in the same or in other lymph nodes may again react to radiation, sooner or later the sensitiveness is lost. In myeloid leukemia, profound changes in the blood picture, in the size of the spleen, and in the patient's comfort result from deep radiation of the spleen, but again the improvement is temporary. These two diseases are often evoked as evidence of the selective action of radium. This action, however, is one of modification of growth, or even possibly of stimulation of certain types of tissue, rather than a destructive effect.

The cells of the ovary and testicle are, again, notoriously susceptible to radiation. Ovarian function and menstruation can be brought to an end by intra-uterine applications of radium, and with all of the symptoms of the menopause. Azoöspermia has been frequently found in male x-ray workers, although there is reason to believe that recovery from this condition may subsequently occur when exposure ceases.

When cancer is superficial and accessible to direct radiation of any desired dosage, either by surface applications or by insertions, it can often be permanently destroyed. In no case of actual cancer, however, has the writer seen success in this purpose without the production of a destructive lesion, and in many there is a failure to destroy the disease entirely. In some cases, as when a basal cell carcinoma involves the bones of the face or a carcinoma of the tongue extends into the tissues of the floor of the mouth, the cancer tissue seems to be more resistant to radiation than the normal issue in the vicinity. In these cases, at least, no specific sensitiveness is manifest.

Advanced cases of cancer of squamous cell or glandular origin which have extended to the regional lymph nodes are frequently subjected to treatment with radium. The enlargement of the regional nodes is commonly accepted as evidence of extension having taken place. However, it must be remembered that other causes for the enlargement of the lymph node exist and that it is not at all uncommon to see an inflammatory process in regional lymph nodes due to the ulceration of the primary carcinoma. Even in the presence of a certain amount of infiltration of cancer cells, inflammatory changes may occur and lead to fluctuation in the size of the lymph nodes far too rapid to be interpreted as being due to cancer growth alone. In almost every fatal case of carcinoma of squamous cell or glandular origin extension of the disease into the regional lymph nodes ultimately takes place. In none of these cases has the writer seen a permanent destruction of the disease following radiation. Shrinkage in size of a large node is observed, but he is inclined to attribute this, when it occurs, to a change in the accompanying inflammatory process rather than to a destruction of cancer tissue.

Cells engaged in mitotic division are generally believed to be more sensitive to radiation than resting cells. The large number of

mitotic figures is a characteristic of cancer tissue. It is not unreasonable to suppose that a part, if not the greatest part, of the supposed sensitiveness of cancer tissue to radiation is dependent upon the number of cells actually undergoing mitosis during the period of exposure. If this is so, a fractional destruction of the tumor only can be expected as a result of repeated deep radiation, for during each exposure only those cells then in mitosis would be affected, and a diminishing but constant residue of unaffected cells would always remain to awaken into activity and grow at some subsequent time and produce recurrence. It must be recognized that there is abundant evidence that repeated exposure to radiation produces a gradual loss of sensitiveness on the part of the tissues exposed, so that the attempt to accomplish a fractional destruction of tumor tissue by deep radiation is by this fact, also, made more difficult. The clinical observations of the result of deep radiation on cancer tissue are in accord with this theory, for although inhibition or retardation of growth may be observed, the destruction of the tumor and the cure of the disease are not accomplished.

In general, the experience in the clinic and in the laboratory has shown that the massive destructive effect of radiation (by direct application) is necessary for the cure of the disease.

While certain tissues show a sensitiveness to deep radiation which is of value in the treatment of non-malignant disease and in the palliative (non-curative) treatment of malignant disease as well, the cure of cancer (estimated in surgical terms on a three to five year basis) is not accomplished without the massive and total destruction of the tumor by the direct application of the source of radio-activity.

K. F. Kesmodel.

Quick, Douglas. The Combination of Radium and the X-Ray in Certain Types of Carcinoma of the Breast. (*Surg., Gynec. & Obst.*, Vol. xxxii, No. 2, Feb., 1921.)

The writer reviews the existent literature briefly, and quotes some interesting early results. He notes that in the past, radium and *x*-ray have not been sufficiently combined. He describes the technique in use at the Memorial Hospital for burying emanation tubes in the tissue; presents an outline of the histologic changes which follow such a procedure and which furnish a rational basis for radium therapy. He thinks that the results following the burial of small emanation tubes (2 or 3 mc.) are better than those following the same total dosage delivered in a shorter time. Filtration, in this method, is through a thin glass wall only, and this permits the use of nearly all of the beta radiation—a very important factor. Subsequent *x*-ray treatment is carried out as though no radium treatment had been given. During the past two and one-half years, 78 cases of carcinoma of the breast have been thus treated at the Memorial Hospital. Of these, 7 show complete regression, and have remained well for periods of from three months to two years; 21 cases show a partial regression, and are still progressing (no case in this group has been observed less than five months); 24 cases showed temporary benefit; 19 of these have died, but without lighting up of the original process; 10 cases showed no improvement (these were far advanced cases with widespread metastases); 9 cases were not followed; 7 cases have been under observation too short a time for any report; 12 of the foregoing cases are reported in detail, with micro-photographs illustrating the histologic changes occurring; 58 of these cases were treated for recurrences and metastatic growth; only one of these was operable. He notes that radium seems to control the pleural pain better than *x*-ray. He concludes that the *x*-ray is useful in the treatment of every case of mammary carcinoma; that radium may be combined with *x*-ray to great advantage in a certain number of cases; that radium is useful mainly in flat or bulky recurrences, axillary involvement, inoperable primary cases; and in cases refusing operation; and that radium and *x*-ray may convert an inoperable case into an operable one at times.

Lowell S. Goin.

Baejter, F. H., and Friedenwald, Julius. Roentgenological Aspects of Lower Right Quadrant Lesions. *Am. J. Med. Sc.*, November, 1920, clx, 639.

The importance of lesions of the right lower quadrant is quite evident. Among the most frequent lesions occurring in this locality may be mentioned:

1. Appendicitis.
2. Incompetent ileocecal valve and ileal stasis.
3. Dilatation of the cecum with retention.
4. Adhesions and angulations.
5. Ulcerations due to tuberculosis.
6. Ulcerations due to carcinoma.

Both bismuth meal and enema are employed. The ingested meal should reach the cecum in five to eight hours, according to the meal employed. Delay in the passage of the meal may be due to dilatation of the cecum, to ptosis or adhesions, to ileal stasis and angulation, ulceration or carcinoma. A bismuth enema, given in the knee-chest position, is also of advantage in studying lesions of the right lower quadrant.

1. *Appendicitis.*—Acute appendicitis may be more accurately diagnosed by filling the cecum to localize the site of involvement and then (in certain instances where the onset of a lower right pneumonia is preceded by symptoms simulating appendicitis) to rule out involvement of this organ by showing the absence of a painful point over the cecum or any limitation of mobility.

Chronic appendicitis: The appendix can be examined only if the lumen is potent and will admit bismuth; otherwise it cannot be visualized. The specific technique emphasized by Case for examination of the appendix is as follows:

(1) Examination of the patient on the horizontal fluoroscope. The tube must be under the table and the screen over the abdomen, to insure the proper examination.

(2) The abdomen must be palpated with the gloved finger or a spoon for localization of a point of tenderness.

The time of examination is of importance. In six hours the cecum fills, and under palpation the appendix may fill. From then on until the bowels are empty it may be visible. When the appendix remains visible for more than a day or two after the bismuth examination it is a dangerous appendix. The bismuth-filled appendix has been noted weeks after an examination. Where there is no local tenderness on pressure, appendicitis can usually be excluded. Where the cecum is limited in motion there is always the possibility that this may be due to inflammation even if the appendix is visualized and not tender. The frequency of visualization of the appendix with bismuth meal varies with different men—35 to 90 per cent. Not every visualized appendix is abnormal. The mere filling of the appendix does not necessarily indicate pathology. When it is curled up, kinked or bound down it probably is pathological.

The stomach is often pulled toward the right lower quadrant due to omental adhesions. As a reflex condition chronic appendicitis may give rise to a picture similar to that of duodenal ulcer; gastric and duodenal hypermobility, with a definite filling defect of the duodenal cap.

2. *Incompetent ileocecal valve and ileal stasis.*—In one sixth of 3000 cases examined by Case incompetency of the ileocecal valve and ileal stasis was noted. Bismuth meals which after twenty-four hours had completely left the ileum were found at thirty-six and forty-eight hours to have regurgitated through an incompetent ileocecal valve into the ileum. The patient should be on his back on the horizontal fluoroscope. The rectal point should be inserted not more than one or two inches. The container of the barium enema should never be elevated more than two feet. Ordinarily 1200 c.c. (100° F.) will fill the colon without causing irritation. The cecum must be well filled and palpated under the fluoroscope. Plates should be made with the patient in the prone position. When a bismuth meal is given it collects in the terminal ileum in about four hours and leaves in eight to nine hours. Delay in passage may be due to spasm, incompetency of the ileocecal valve, bands of adhesions, displacement, prolapse or tumors; dilatation of the terminal ileum points to obstruction.

3. *Dilatation of the cecum with retention.*—The ingested bismuth meal appears usually in the cecum in from seven to ten hours. Delay in passage may be due to dilatation and retention of cecum. This may be associated with constipation, appendicitis, sub-acute inflammatory lesions, or enteroptosis. It is not the position of the cecum which is most important but the function of this part of the bowel. The constipation associated with this condition may be very marked and on operation the retained fecal material may cling closely to the walls of the cecum leaving bleeding areas when separated, showing evidence of a subacute infection.

4. *Adhesions and angulations.*—Angulations

and kinks occurring in the right lower quadrant are often due to adhesions either from appendiceal disease, pelvic inflammation or some local inflammatory process. The delay in the passage of the bismuth will give a clue to this.

5. *Ulcerations from Tuberculosis.*— The clinical picture of intestinal tuberculosis is of little aid in early cases. The roentgenographic examination may give definite information. The most constant finding is intestinal hypermotility, the entire meal being discharged in twenty to twenty-four hours; this may be with or without gastric residue. A spastic condition of the bowels affecting especially the cecum and ascending colon is noted and often irregular filling defects can be seen.

6. *Ulcerations from carcinoma.*—There is in this condition a large irregular constant filling defect of the cecum. Filling defects from adhesions and fecal contents must be carefully differentiated by re-examination at a later date.

In conclusion, the *x*-ray examination should be looked upon as an aid in the diagnosis of the lesions above indicated. The possibility of error is so great that mistakes will necessarily be made. If the roentgen diagnosis is diametrically opposed to the clinical and all other findings it is probably wise to adhere to the clinical interpretation.

L. R. S.

HERNAMAN-JOHNSON, FRANCIS. The Use of X-Rays as Immunity-Raising Agents before and after Operation for Cancer. (*Brit. Med. J.*, June 12, 1920.)

The knife may be a means of disseminating stray cancer cells. If before this occurs we can bring about either a weakening of the malignant cells or an increase in the resistance of the body tissues, or both, the chance of successful colony formation by the parent growth will be lessened. Experimental research has shown that mouse cancer which has been exposed to radiation is grafted into fresh tracts with difficulty or not at all. Clinical evidence supports this fact as applied to man. The *x*-rays act as much by their stimulating or regulating action upon the body as by their depressing effect upon cancer. Embryonic cells are injured or destroyed by doses of radiation which have little or no effect upon the normal tissue. The general stimulating and regulating action of the *x*-rays is of more value than their specific effect upon the pseudo-embryonic cells. The immunity produced by *x*-rays is partial and non-specific. It is not proven that that resulting from the use of radium is any different. Pre-operative treatment should be given. The healing of the wound is not delayed and the only argument against such a procedure is that it delays operation for two or three weeks. This argument, to be valid, implies that the cancer, though improving visibly, is invisibly spreading in depth. This does not occur. If immunity to cancer can be raised by pre-operative raying, we should obviously carry out raying after operation. So long as we are not dealing with actual recurrence, we should be careful to give too little rather than too much. The fact that small doses increase the immunity to cancer and that large ones decrease or abolish it must be kept in mind.

LOWELL S. GOIN.

MARTY, L. A. The Modern Treatment of Malignancies. (*J. Missouri Med. Assn.* Vol. XVII, No. 7.)

In the United states 65,000 people died of cancer in 1918; 200,000 people are suffering at all times from this condition. We are no longer justified in "cutting it out" and allowing the percentage of recurrences to be high and the mortality what it is at present. Only the man doing *x*-ray work and radium therapy will be able to do work that is fair to the patient, for specialists are not made over night in this more than in any other special branch. Breast cases, for example, should have preliminary raying to block the lymphatics and lower the vitality of the malignant cells. A massive dose should be delivered into the wound before closure of the flaps and post-operative raying should be begun as soon as the patient has recovered from the shock of the operation. The axillary and clavicular regions, and in fact the entire chest should be rayed. The same applies to malignancy elsewhere. In cancer of the pelvic organs radium may be added to advantage. Radiation is indicated in every case, as much suffering is relieved, toxemia lessened, and the patient made more bearable to those about him.

L. S. G.

HUBENY, M. J. *X*-Ray Treatment of Exophthalmic Goiter. (*Illinois Med. J.* June, 1920, p. 383.)

The writer reviews briefly the history of *x*-ray therapy in goiter and sums up the histologic basis for such treatment. He has used two techniques, one is to give each of these areas (including the thymus) two thirds of an erythema dose, using a 9 inch spark-gap and filtration of 4 millimeter aluminum and one millimeter leather with target skin distance of 8 inches. This dose is repeated in three weeks. The second technique consists in using the same filtration, the same spark-gap and a 14 inch skin distance, applying a half-erythema dose over each of six areas: right anterior thymus; left anterior thymus; right anterior thyroid; left anterior thyroid; right and left posterior cervical ganglionic areas. Roentgenization over the cervical ganglionic areas inhibits thyroid secretion. The second technique is preferred when the patient is not highly toxic, quicker results are obtained with the first technique. Early treatment increases the chances of recovery, exophthalmos disappears in 40 per cent of cases. The first dose should be small to guard against an increased toxemia. Caution should be used in treatment of cases after operation, as there is danger of the production of hyperthyroidism.

L. S. G.

FISCHEL, ELLIS. The Use of Radium in Carcinoma of the Face, Jaws and Oral Cavity. (*J. Missouri Med. Assn.* Vol. XVII, No. 7.)

The recognized methods oftreatment are operative removal, destruction by *x*-ray, radium, high frequency or the actual cautery. The *x*-ray can be relied upon to cure nearly all basal cell epitheliomas of the fact. At present it cannot be depended upon to destroy the more malignant types even when located on the surface. The writer has never seen a lesion located within the mouth benefited by the *x*-rays. Radium has some advantages over the *x*-ray, particularly the fact that a known amount may be buried in a mass. Whatever means are employed, the tumor should be destroyed as completely as possible at the first attempt. If cancer of the lip, the results under radium treatment have been so striking that operation is no wreserved for those who have had paste or unsuccessful operative treatment before. Results within the oral cavity have not been so successful, no cures having been noted. If the growth involves the bony jaw, operation is advised, and is followed by radium.

L. S. G.

VILRANDE, G. E. Observations on the Treatment of Neoplasm. (*Brit. Med. J.*, February 14, 1920.)

The writer reports a number of interesting case histories of various malignancies treated by radium. He thinks that there is no doubt as to the value of radiation of the site of glands after removal, and pleads for the routine raying of the scars after lip operations. Rodent ulcers do best under radium. Sarcomata are much more easily inhibited than are carcinomata. Breaking down malignant glands as follow an epithelioma of the lip, does not do well under *x*-ray treatment. Neoplasm of the lungs reacts to hard, heavily filtered rays, but the writer has not seen one disappear. He suggests that perhaps the frequent occurence of epithelioma on lupus that has been treated by small doses of unfiltered rays may have some significance. Larger doses of harder, more heavily filtered rays are indicated in radiotherapy. The writer has doubled and tripled his dosage in the past two years.

LEIGHTON, W. E. Inoperable Cancer. (*J. Missouri Med. Assn.* Vol. XVII, No. 7.)

The responsibility for inoperable cancer rests (1) with the quack cancer specialist, (2) with the patient who neglects to consult a physician, (3) with the physician who fails to recognize the disease, or who attempts superficial surgery. The diagnosis of external cancer is not very difficult. Ulcerations which do not heal readily should arouse our suspicions, and tumors of all descriptions demand early investigation. The laity and the physicians must be educated to the fact that early diagnosis and operation will cure a large percentage of cancer cases. Palliative operation should be undertaken where possible. The re-

moval of ulcerating and offensive masses by cauterization, electro-thermic coagulation or electric dessication may accomplish wonders. Deep roentgen therapy after removal of the skin has given excellent results.

L. S. G.

Semon, H. C. The *X*-Ray Treatment of Acne Vulgaris. (*Brit. Med. J.*, May 22, 1920.)

The etiology and pathology of acne is that the effect of the rays on acne lesions is the inhibition of the physiologic action of the secretory cells of the sebaceous glands, and the dissolution of the fibrous capsules of the infected comedo. Whether or not this is correct, it remains a fact that the *x*-rays will cause involution, both of the comedo and the deep nodular abcsess and reduce scarring to a minimum. For simple cases unfiltered rays from a tube backing up between 4 and 5 inches spark-gap are used, giving a dose of four fifths Sabauraud B tint. This is not repeated within ten days. An erythema is not desirable.

When pustulation and dermatitis are marked, treatment is preceded by a few days' application of antiseptics and detergent lotions, after which doses of two-fifths B tint are given at ten-day intervals. In the more advanced stages, with intra- and sub-dermic nodules, periglandular fibrosis, etc., harder rays from a tube backing up between 5 and 6 inches of spark-gap are used, with five millimeters of aluminum filter, giving a full pastille dose. After two weeks half-pastille doses may be given at ten-day intervals. Local relapse is rare.

Acne can be permanently cured, no matter in what stage it may be, by judicious *x*-ray treatment.

L. S. G.

Bryan, Lloyd. The *X*-Ray as an Aid in Diagnosis of Non-Tubercular Pulmonary Conditions. (*California State J. Med.* Vol. XVIII, No. 6.)

Lung abscess is seen as an irregular area of increased density, fading out gradually into normal lung tissue. If the cavity is only partly filled with fluid, a gas bubble may be seen above the fluid level. The large area of consolidation about the cavity may be misleading, and the surgeon will be disappointed in finding so small a cavity. Abscess must be differentiated from bronchiectasis in which condition the indurated areas are usually multiple. The peribronchial thickening of bronchitis never reaches the periphery. Primary and secondary pulmonary malignancy must be differentiated from both lung abscess and tuberculosis. Metastatic sarcoma give a picture identical with that of multiple small abscesses. Tuberculosis may be confused with pneumoconiosis, and may be coincident with it. Diagnosis should not be made from an *x*-ray examination, which is only an aid, and must be correlated closely with the clinical findings.

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THE ABSORPTION OF RADIUM RADIATIONS BY TISSUES

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THIS investigation was undertaken for the purpose of determining the absorption by different tissues of the radiation of radium filtered through various thicknesses of metal. The scope of the work was to apply the knowledge thus obtained to radium therapy.

DESCRIPTION OF APPARATUS

The apparatus used for the experiments is shown in Figure 1. The conical ionization chamber is made of lead, and is supported vertically on a suitable frame not shown in the diagram. It is 51 cm. long, 3 cm. in diameter at the smaller end, and 12 cm. at the larger end. The wall thickness is 0.8 cm. A thin steel rod, tapered to a point, is suspended along the axis of the chamber, and is carefully insulated therefrom. The rod is electrically connected to the leaf post P of the electroscope by means of a fine copper wire which runs through brass tubes filled with paraffin. The electroscope is made of lead 1 cm. thick. The inside dimensions are 2.7 by 6 by 7 cm. It is arranged (as shown in the lower part of the figure) so that the gold leaf is projected on a ground glass screen. The lead cone, brass tubes, and electroscope case are all connected to the ground at G. The gold leaf of the electroscope is charged by pulling a string attached to a bell crank, so that the rod R, which is connected to a suitable source of potential, touches the leaf post. The wire in the ionization chamber will then be at the same potential as the leaf. The charging potential is adjusted so as to bring the image of the leaf always to the same point *a* on the screen. In taking readings, the observer sits in front of the ground-glass screen, and, with a stop watch, measures the time it takes the image of the leaf to travel between the points *b* and *c* on the screen.

The supports for the source of radiation, filter, and tissue, are made of hard rubber and very thin mica, as shown at AB. They are placed at such a distance from C that the source of radiation is practically at the apex of the cone. In this manner the beam of rays which enters the cone fills the whole chamber. The metallic filters are placed just above the radioactive source; the tissue is placed on the mica window B which is 1.5 cm. above the support for the filters. With this arrangement it is possible to change the filter without disturbing the tissue in any way. The lower end of the ionization chamber is closed by a very thin sheet of mica.

The radiation we wish to measure is only

the beam which enters the ionization chamber. It is necessary, therefore, to shield the electroscope itself from the radiation which the source emits in all directions. For this purpose a thick block of lead is interposed between the source and the electroscope, and the latter is so constructed that no stray radiation can enter it. The brass tubes are filled with paraffin for the same purpose of limiting the effect of the radiation to the air in the ionization chamber proper. The instrument was tested to see whether the shielding was sufficient, and it was found that the effect on the electroscope which was not due to the ionization chamber was negligible. Account had to be taken, however, of the "natural leak" of the instrument, that is, of the slow discharge of the electroscope leaf when the source of radiation which we wished to investigate was not present. This correction is made by subtracting the rate of fall of the leaf due to the natural leak alone from the rate of fall due to the combined effect of the radiation which enters the ionization chamber, and the natural leak.

It is important to bear in mind just what we are measuring with an apparatus of this sort, because on that depend the conclusions which we may draw from the experimental results. The cone of rays which enters the ionization chamber ionizes the air in it. The formation of ions implies that energy is being used up in the process, since work must be done to separate negative from positive electricity on account of the force of attraction between the two. This energy is supplied by the radiation. The difference of potential between the wire and the walls of the ionization chamber is sufficient to cause the positive and negative ions to be separated from each other as soon as they are formed, thus preventing their recombination. Under these conditions the electric current thus produced is proportional to the number of ions produced per second, which is a measure of the energy absorbed by the air in the chamber. The electroscope, used in conjunction with a stopwatch, measures this ionization current. Consequently the readings which we obtain in this manner are proportional to the energy absorbed.

The physiological action of radiation is dependent to a considerable extent on the amount of energy absorbed by the radiated tissue. It is evident, therefore, that ionization methods of measurement offer a good basis for the correlation of the physical factors of the dose of radiation administered and the physiological effects produced thereby. The method, however, has its limitations, which should be clearly recognized. In the first place, the medium in which the ionization is measured is a gas, and not tissue. When the constituents of the gas do not differ very much in atomic weight and relative proportions from the constituents of tissue, the absorption of radiation, mass per mass, is substantially the same. If we assume this to be true in the case of air, the thickness of tissue equivalent to the air in the ionization chamber of these experiments is about 0.6 mm. Secondly, the ionization of the air in the chamber consists of two parts, that produced directly by the passage of the beam of radiation through the air, and that produced by the scattered and secondary radiation excited by the rays which impinge on the walls of the chamber. When a metal ionization chamber is used, as in this case, the second term may be very important, according to the character of the radiation. Thirdly, the scattered and secondary radiations, which contribute to the effect in a deep-seated tumor, for instance, are quite different from their counterparts in the ionization chamber. These are the main physical differences between the conditions obtaining in laboratory experiments and in the treatment of patients. It is evident, however, that there are greater differences which are independent of physical conditions, but which are due to the inherent peculiarities of living matter. The physiological action of radiation depends not only on what takes place in the radiated tissue, but also on the reaction of the whole system. Naturally we cannot simulate this in *physical* experiments. Hence, in order to make practical application of the

results obtained from physical experiments, it is necessary to conduct physiological experiments complementary to the former.

EXPERIMENTAL PROCEDURE

To determine the absorption of radiation by tissue it was necessary to have uniform parallel slices of tissue about 5 cm. square. The thicker slices were cut by hand, using a knife with a wide blade. The thin slices were cut by means of a meat-slicing machine with a specially ground knife, after the tissue had been frozen hard. Tissue hardened in formalin could be cut with this machine without trouble. The thickness of the slices of tissue was determined by placing each between two thin sheets of lead and measuring the total thickness with a micrometer caliper. When the thickness of tissue on the mica support was several centimeters, the total thickness was checked by placing a steel scale against the pile of tissue. This procedure was especially necessary in the case of a very soft tissue, because its weight flattened the bottom layers. The density of the tissue was determined as follows: The tissue, in one or several pieces, was weighed with an accurate balance. Its volume was then determined by measuring the amount of water which it displaced, and the density obtained by dividing the mass by the volume. The weight of the tissue used for this determination was in every case several hundred grams. For the metals and solid bone the volume was calculated from the dimensions of a rectangular slab of the material.

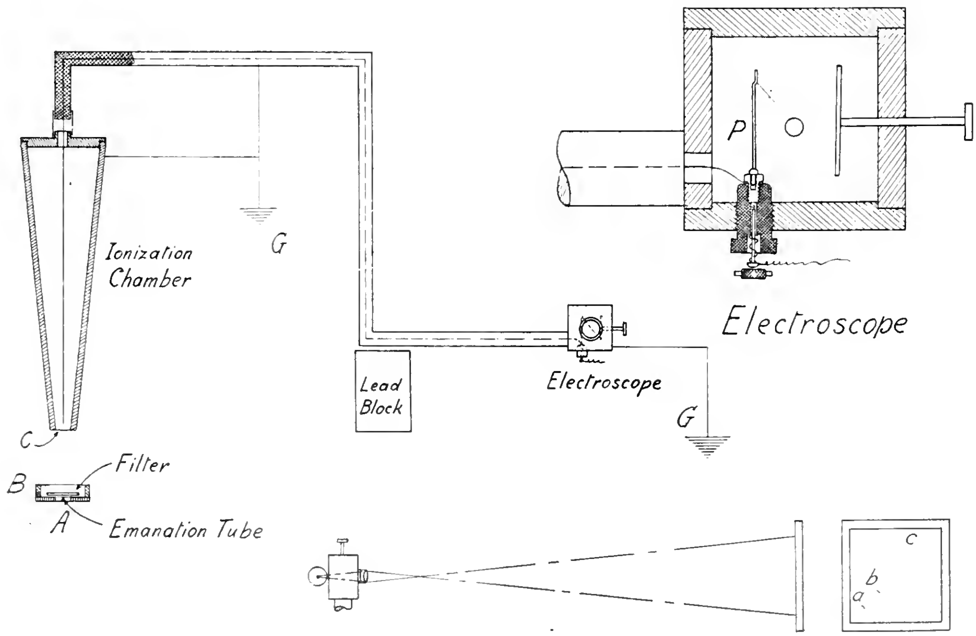


FIG. 1 Projection of Gold Leaf on Ground Glass Screen

The source of radiation used for these experiments was radium emanation enclosed in capillary glass tubes about 0.5 mm. in outside diameter and 14 mm. long. While the wall thickness of these tubes is sufficiently great (about 0.1 to 0.15 mm.) to absorb the alpha rays, it has little effect on the beta and gamma radiations. If such a tube, containing a suitable amount of emanation, is placed at A in the apparatus of Figure 1, the radiation will go through the very thin mica sheets at

B and C and will enter the ionization chamber without appreciable absorption. There it will ionize the air, and the electroscope will measure the ionization thus produced. Let us arbitrarily call the intensity of ionization in this case 100 units. If we place a slice of tissue 1 mm. thick on B, the radiation which enters the ionization chamber is only that part of the original beam which succeeded in getting through 1 mm. of tissue. This produces an ionization of 43 units in the chamber as measured by the electroscope. The addition of another millimeter of tissue (a total thickness of 2 mm.) reduces the ionization to 27 units. Continuing in this manner, for larger thicknesses of tissue, we obtain values of the intensity of ionization for different thicknesses of tissue interposed between the source of radiation and the ionization chamber. The results are shown graphically by curve A in Figures 3 and 4. A similar procedure using a metal or a metallic filter and tissue enables us to obtain the absorption curves shown in Figures 2, 3, and 4.

DISCUSSION OF ABSORPTION CURVES

In these experiments the ionization produced by the total radiation, beta and gamma, emitted by an emanation tube, was assumed to be 100 units. All other readings, therefore, represent percentages of the total radiation. As the range of values to be incorporated in the absorption chart is large, it was thought best to use a logarithmic scale. In this way, as the values decrease the scale is automatically increased. Furthermore, a logarithmic scale has the important advantage that it enables us to tell at a glance when the radiation becomes "homogeneous," because in this case the absorption curve is a straight line. For our purposes the radiation is homogeneous when successive equal layers of tissue absorb the same percentage of the radiation which reaches them. This means that the quality of the radiation remains substantially the same as it goes through the filter or tissue.

In Figure 2 are shown the absorption curves for different metals. It will be seen that the curves for metals of medium or low atomic weight become straight lines beyond a thickness of metal of a few millimeters. The curve for lead, on the other hand, does not become straight in the range of thickness shown in the chart. The mathematical law of absorption which applies to the straight part of the curve is

$$I = I_0 e^{-\mu d}$$

where I_0 = intensity of radiation falling on filter,
I = intensity of radiation passing through the filter,
d = thickness of filter,
e = Naperian base of logarithms,
μ = the coefficient of absorption.

The coefficient of absorption represents the fraction of the incident radiation which is absorbed or scattered per unit thickness of filter.* For the same quality of radiation, this is different for different absorbers, and for the same absorber it is different for different qualities of radiation. In the case of aluminum, for instance, the value obtained from the curve of Figure 2 is 0.11, and therefore 11% of the gamma radiation is absorbed per centimeter of aluminum. (The value given by Soddy and Russel[1] is 0.111, and by Rutherford and Richardson[2] is 0.115.) In the case of brass the value of μ for gamma rays is 0.35, so that brass absorbs $\frac{0.35}{0.11} = 3.2$ times more gamma radiation per unit thickness than aluminum. The thickness of lead used in these experiments (2 cm.) was not sufficient to give a straight line in the absorption curve. Hence it is not strictly correct to speak of a coefficient of absorption for this curve. However, if we make the calculation for the last part of the curve we find that μ equals 0.58, which is somewhat higher than the value of 0.5 given by Rutherford.[3] This shows that the hard-

* In thinking of the coefficient of absorption in these terms, care should be exercised to choose a unit of thickness which will make the amount of radiation absorbed by a filter of unit thickness a small fraction of the incident radiation.

ness of the gamma radiation from radium increases with the thickness of filter beyond 2 cm. of lead. In fact, from the experiments of Tuomikoski[4] and others, it appears that the penetration of the gamma radiation of radium increases even after filtration by several centimeters of lead. Such excessive filtration, however, is entirely out of the question in radium therapy, on account of the weight of the filter and the diminution of the quantity of radiation which passes through it. Even for 20 mm. of lead the ionization produced by the transmitted radiation is only 1.5% of the value for the unfiltered beta and gamma radiation, and less than ¼ the value for radiation through 1 mm. of lead.

Fortunately no such filtration is necessary in therapy. In the first place, the fact that the aluminum and brass curves become straight lines beyond a thickness of a few milllimeters indicates that radium radiation filtered through 6 mm. of aluminum or 2 mm. of brass is sufficiently homogeneous to be absorbed by these metals according to the exponential law given above, within the range of thicknesses shown in Figure 2. The reason is that for substances of low atomic weight the coefficients of absorption as here defined do not vary much with the wave length, for gamma radiation of the quality considered.[5] *A fortiori* this is true of the absorption of tissue, the principal constituents of which are much lighter than these metals. In the case of lead, the mechanism of absorption is further complicated by the fact that the element is an isotope of Radium B.[6]

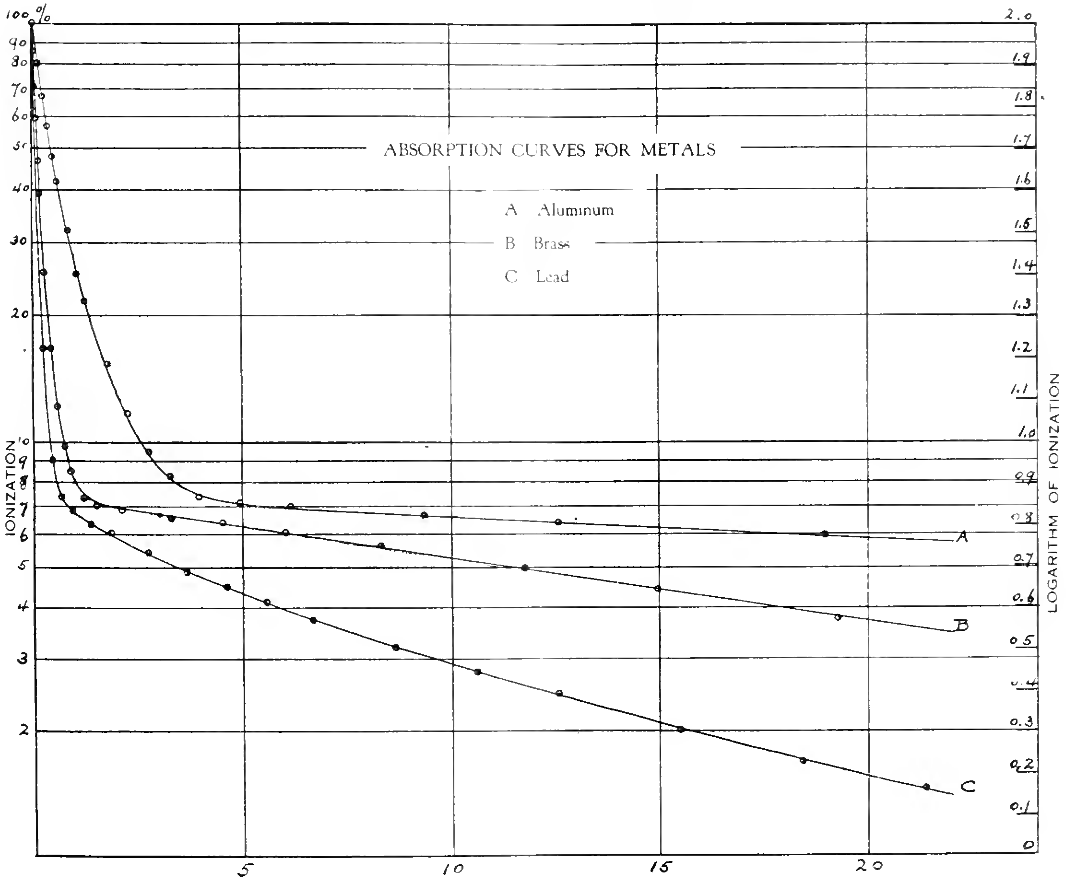


FIGURE 2.

In Figures 3 and 4 are shown the curves of absorption by tissue of the radiation filtered through different thicknesses of brass and lead respectively. The circles indicate the points which were experimentally determined. The largest thickness of tissue used in these experiments was about 7 cm. For this reason the prolongation of the curves to 10 cm. is shown in dotted lines. We are justified in extrapolating to 10 cm. because many other curves we have obtained in the course of our work, using up to 9 or 10 cm. of tissue, have been straight lines, within the limits of experimental error. In either chart the highest curve is for the total radiation, beta and gamma, emitted by the small capillary glass tube containing radium emanation. It will be seen that there is a sharp bend in the curve corresponding to a thickness of about 1 cm. of tissue. This is the point at which a transition occurs in the quality of the radiation, from a preponderance of beta and soft gamma rays to a preponderance of hard gamma rays. The presence of soft radiation is evident, however, even up to thicknesses of tissue of 5 or 6 cm.

The lowest curve, F, in either set represents the absorption of radiation by the metal filter alone. These curves are the same as shown in Figure 2, but plotted to a different scale. The absorption curves for filtered radiation branch out from these curves. The filters used were approximately 1/2, 1, 2, and 3 mm. of either brass or lead. For any point on the curve the thickness of tissue is added to the thickness of filter. Thus for the third curve, C, in Figure 3, we have: a brass filter 0.96 mm. thick reduces the ionization from 100 to 7.6%, the further addition of 1 cm. of tissue brings the ionization to 6.2%, and so on. The curves are plotted in this manner so that each is a complete absorption curve, starting with unfiltered radiation.

For deep therapy it is essential to use radiation which is absorbed exponentially by tissue; that is, radiation which is absorbed to the same extent by successive layers of tissue. If this is not the case, the skin and superficial layers will absorb a larger percentage of the incident radiation than corresponding layers of tumor tissue, and therefore will be affected more strongly, even if it were possible to use a parallel beam of radiation. As the dose is adjusted so as not to injure the skin, it follows that by using a filter which does not give a homogeneous radiation, the tumor does not receive as much radiation in proportion as it would if sufficient filtration were used. Thus, if the filter consists of 1/2 mm. of brass, from Figure 3 we see that the first centimeter absorbs $\frac{14.5 - 6.4}{14.5} = 56\%$ of the incident radiation, the second centimeter absorbs 9%, but the third and each subsequent centimeter absorbs only 7.7%. On the other hand, using 2 mm. of brass as a filter, the first centimeter absorbs 10%, the second, third, etc., 7.5%, and the difference, which in this case is due to the secondary radiation of brass,[7] is small. The further addition of a secondary filter of 2 or 3 mm. of rubber, which has about the same absorbing power as tissue, makes the percentage absorbed by the first and successive centimeters of tissue the same.

The criterion for the exponential absorption of radiation is that the absorption curve, when plotted to a logarithmic scale, be a straight line. From Figures 3 and 4, therefore, we can determine what filtration to use to fulfill this condition. Evidently there is more than one choice. However, not all possible combinations of primary and secondary filter which could be used are equally economical. In the first place, it will be seen that in no case is the absorption curve a straight line when the ionization is over 6%. This means that at best we can use for deep therapy only 6% of the radiation emitted by the bare glass tube. At this point it is interesting to note that when tissue is used as the absorber, the absorption is not exponential up to a thickness of about 5 cm. Accordingly if tissue or some organic substance of about the same density were used for deep therapy, a thickness of five or more centimeters would be necessary. Aside from the inconvenience

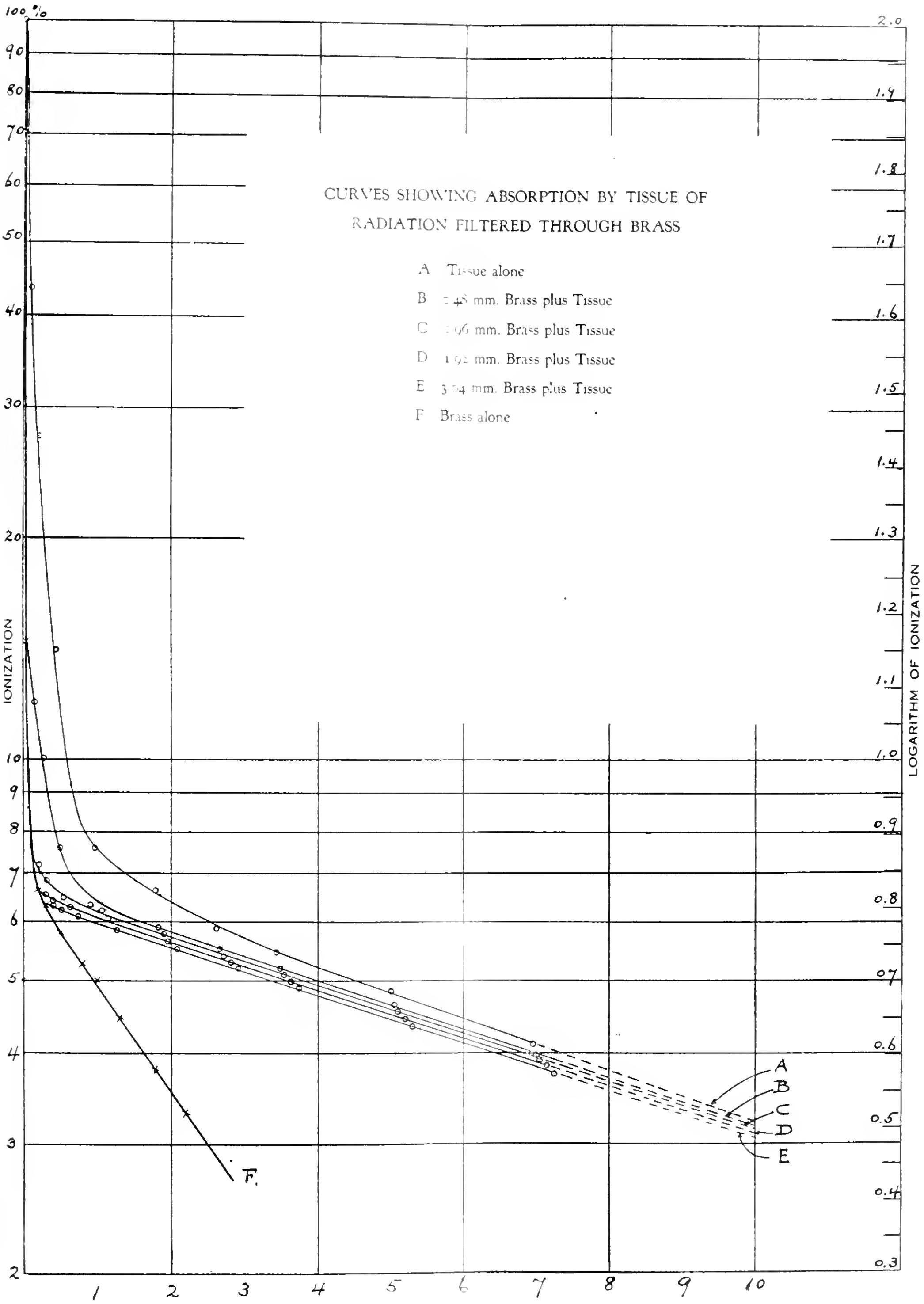
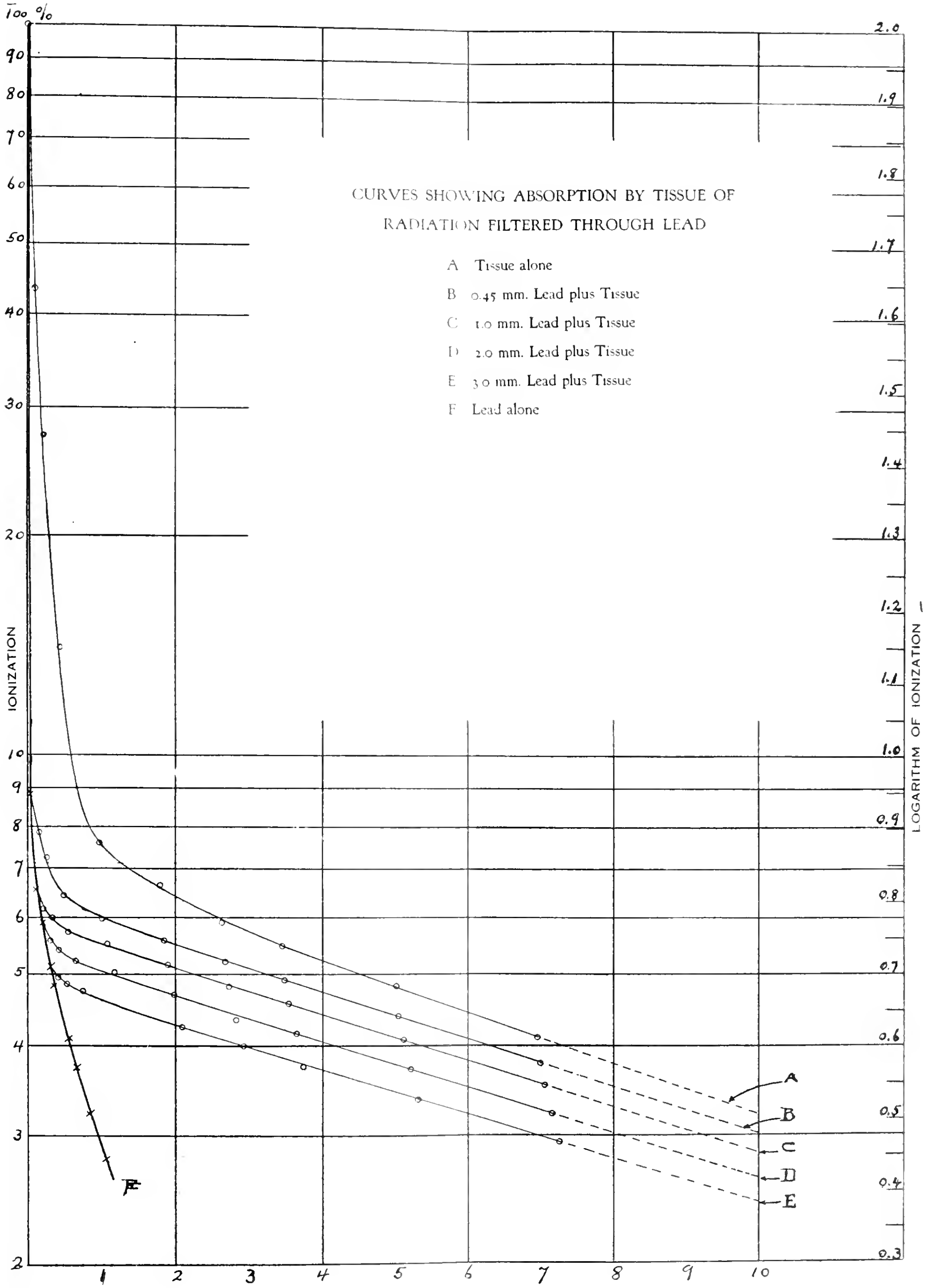

CURVES SHOWING ABSORPTION BY TISSUE OF
RADIATION FILTERED THROUGH BRASS
A Tissue alone
B 0.48 mm. Brass plus Tissue
C 0.96 mm. Brass plus Tissue
D 1.92 mm. Brass plus Tissue
E 3.84 mm. Brass plus Tissue
F Brass alone
IONIZATION
LOGARITHM OF IONIZATION
100 %
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1
2
3
4
5
6
7
8
9
10
A
B
C
D
E
F.

FIGURE 3.

of such a bulky filter, its use would entail an unnecessary loss of radiation, because the ionization produced by radiation filtered through 5 cm. of tissue is 4.8%, while other filters can give 6%. The reason for this is that the diminution of the intensity of the beam of radiation passing through a filter of low atomic weight is primarily due to the scattering of the radiation and not to true absorption. Since the scattering by substances of low atomic weight is not very different for the different qualities of radiation, the softer components of the beam of radiation are not effectively eliminated in this manner. Hence substances of low atomic weight are not efficient filters,[8] and the large thickness required to obtain the proper filtration causes undue scattering and absorption of the penetrating radiation as well. This brings out the desirability of using a metalic filter. In general an additional filter of low atomic weight is necessary to remove the soft, secondary radiation of the metal.[7]

The straight line parts of the curves of Figures 3 and 4 are not parallel, but nearly so. This means that filtration by different thicknesses of the same metal changes the penetrating power of the radiation somewhat. The magnitude of this change can be seen from Table II, in the column for the percentage of radiation absorbed by 1 cm. of tissue. Thus, when the filter is ½ mm. of brass, 1 cm. of tissue absorbs 7.7%, while for 3 mm. of lead filtration the corresponding value is 7.1%. The radiation in the latter case is more penetrating than the former. If we increase the filtration considerably, the penetrating power of the radiation can be increased further.

In deep therapy there are two factors which affect the amount of radiation which reaches the tumor: the distance of the tumor from the source of radiation and the absorption of part of the radiation by the intervening layers of tissue. For any one set of conditions, that is, distance of source from skin, strength and distribution of source, and depth of tumor, the quantity of radiation which reaches the tumor depends on the penetrating power of the radiation. The more penetrating the radiation, the more of it will reach the tumor. From this point of view, therefore, it is obvious that it is desirable to use the most penetrating radiation available. This, however, is not the only consideration involved in the problem. When radium is used as the source of radiation, the only means of obtaining a more penetrating radiation is the use of a heavier filter, which of necessity entails a decrease in the amount of the available radiation. Furthermore, the limiting factor in deep therapy is the effect on the skin, since this is always greater than in deep layers, neglecting any difference in susceptibility which may exist between different tissues. Therefore it is important to know what fraction of the radiation which falls on the skin reaches the tumor. The maximum value of this fraction is determined by the relative distances of the skin and tumor from the source. Thus, if a point source of radiation is placed at a distance of 3 cm. from the skin, and the farthest point of the tumor is 3 cm. below the skin, (i.e., 6 cm. from the source) the most that the tumor can receive is ¼ as much as the skin. This is on the assumption, which can never be realized in practice, that the 3 cm. of tissue intervening between the source and the back of the tumor do not absorb any radiation at all. Allowing for the absorption by the tissue of radiation filtered through 1 mm. of brass plus 8 mm. of rubber, we find that the distant parts of the tumor receive 19.9% of the radiation which falls on the skin, instead of 25%. Using a filter of 3 mm. of lead plus 7 mm. of rubber, the radiation at the back of the tumor will increase from 19.9% to 20.2%; that is, it will be 1.5% greater for the same skin dose. This, however, will decrease the intensity of the source of radiation from 6.3% to 4.6%, or 27%, so that in order to obtain the same skin dose using the same amount of radium the duration of the application must be prolonged 27%. The advantage of getting 1.5% more radiation in the tumor may offset the disadvantage of a longer exposure, but, is there any other



CURVES SHOWING ABSORPTION BY TISSUE OF RADIATION FILTERED THROUGH LEAD
A Tissue alone
B 0.45 mm. Lead plus Tissue
C 1.0 mm. Lead plus Tissue
D 2.0 mm. Lead plus Tissue
E 3.0 mm. Lead plus Tissue
F Lead alone
IONIZATION
LOGARITHM OF IONIZATION
100 %
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1
2
3
4
5
6
7
8
9
10
A
B
C
D
E
F

FIGURE 4.

way of accomplishing the same purpose with greater economy? The relative amount of radiation which reaches the tumor can be increased also by placing the radium at a greater distance from the skin while still using the same filtration as in the first case. Let us determine what this distance should be in order to have 1.5% more radiation in the tumor, that is, 20.2% of the amount reaching the skin. Figure 5 shows the notation used below. The percentage of the skin radiation which reaches the tumor is given by the expression $\frac{100\,x^2}{(x+z)^2} \times e^{-\mu d}$. If this is to be 20.2% when $z = 3$, $\mu = 0.0755$, then

$$\frac{100\,x^2}{(x+3)^2} \times 0.797 = 20.2, \text{ whence } x = 3.1 \text{ cm.}$$

Therefore in this particular case an increase of 0.1 cm. in the distance of the applicator is sufficient to increase the tumor radiation 1.5%. To get the same skin dose the time will now have to be increased in the ratio $\frac{(3.1)^2}{3^2} = 1.068$, or less than 7%. Since in using a higher filtration we found that the time of application had to be increased 27%, it is evident that the same result can be obtained more economically by increasing the distance. This example has been worked out to illustrate this point. In practice, however, an increase of 1.5% would be insignificant. If we had considered the dose at a much greater depth, the effect of a higher filtration would have been larger, and the adjustment in distance to get the same result would have been necessary.

From the law of conservation of energy it follows that, in order to affect the tissue, some of the radiant energy traversing the tissue must be absorbed by it. In fact, as stated in the first part of the paper, there is considerable evidence tending to show that the physiological effect is dependent on the amount of radiation absorbed by the tissue. From this point of view, then, there is an advantage in using radiation which is more easily absorbed by tissue, provided we can obtain the same ratio between the skin dose and the tumor dose, by properly adjusting the distance of the applicator. This simply means that for the same total amount of radiation falling on the skin a given physiological effect can be obtained in a shorter time in the case of the softer radiation. As, however, the time element does not influence the ratio between the skin dose and the deep dose, it will be seen that the fact that tissue absorbs more of the softer radiation does not tend to increase the deep dose in comparison to the skin dose. On the contrary, it is very effective in decreasing the amount of radiation which reaches the deeper layers of tissue.*

In the light of what has just been said, it is reasonable to ask: Can we obtain the same relative dose of radiation at a certain depth of tissue by using *x*-rays and placing the tube at a greater distance from the skin? The answer to this question depends entirely on the quality of the *x*-radiation available. In the example given above it will be seen that the controlling element was the "dispersion" of the radiation and not the absorption. Considering the effect of distance alone, the dose at a depth of 3 cm. was only 25% of the dose on the skin, that is, there was a loss of 75%. On the other hand, the loss due to absorption by 3 cm. of tissue was 20.3%, which is small in comparison. In the case of *x*-rays the conditions are reversed. The target-skin distance probably would not be less than 20 cm. Then for a tissue depth of 3 cm. the dose, neglecting absorption, would be $\frac{(20)^2}{(23)^2}$ or 75.7% of the skin dose. To get the same percentage of the radiation as in the previous case, that is 20%, we can now afford to lose 55.7% through absorption. Using the same equation as before we can

* In working out the above example no account was taken of the above mentioned effect of the quality of the radiation on the time of irradiation. This is justified because the quality of the radiation in the two cases was only slightly different, and under these conditions the ionization method of obtaining the absorption curves used in solving the problem automatically compensates for the difference in the absorption of the two types of radiation.

determine the degree of penetration which the x-rays must have in order to get at a depth of 3 cm., 20% of the radiation falling on the skin.

$$x = 20,\ z = 3.\ \frac{100 \times 20^2}{(20 + 3)^2}\ e^{-3\mu} = 20.$$ Therefore $\mu = 0.443$. That is, when a homogeneous x-radiation is $\frac{0.443}{0.0775} = 5.87$ times less penetrating than the gamma rays, and the target is at a distance of 20 cm. from the skin, we get at a depth of 3 cm. of tissue 20% of the radiation falling on the skin. If, however, for the purpose of comparison, we place our radium source at a distance of 20 cm. then the dose at a depth of 3 cm. is 60% of the skin dose instead of 20%.* In practice it is desirable to have as little difference as possible between the skin dose and the tumor dose. This condition would obtain if the source were placed at a great distance from the skin; that is, for parallel rays. Then the only factor which limits the radiation at any depth is the absorption. If parallel radiation were used, we would get at a depth of 3 cm. 79.7% of a skin dose in the case of gamma rays, and 26.4% in the case of x-rays six times less penetrating than gamma rays.†

Table I gives the relative amounts of radiation reaching different tissue depths for different conditions of application.

A comparison of columns F, B, and D shows that when the distance of application is increased from 3 cm. to 20 cm., the radiation at a depth of 3 cm. increases from

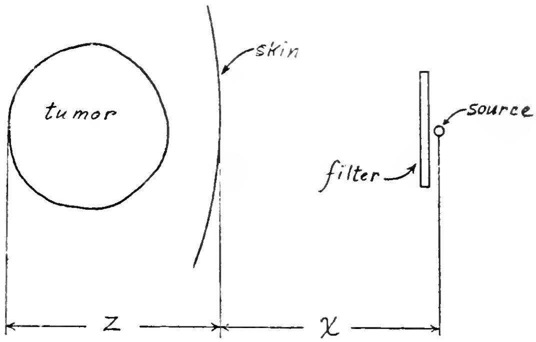


FIG. 5. Diagram showing relative positions of tumor, skin and source of radiation.

19.9% to 60.2%, while the theoretical maximum for infinite distance is 79.7%. From this we see that when the distance of application is great in comparison to the tissue depth, further increase in the distance is of little help in increasing the tumor dose. The values in columns F and G show that when the distances are adjusted so as to get the same skin dose and the same tumor dose at a depth of 3 cm., using radiation of different degrees of hardness, the doses are not the same at any other tissue depth, and especially at greater depths than the one for which the

TABLE I

A	B	C	D	E	F	G
Tissue depth cm.	*Source 20 cm. from skin*		*Source at infinite distance*		*Ra. 3 cm. from skin*	*Target 20 cm. from skin*
z	Gamma rays $\mu = 0.0755$	X-rays $\mu = 0.443$	Gamma rays $\mu = 0.0755$	X-rays $\mu = 0.443$	Gamma rays $\mu = 0.0755$	X-rays $\mu = 0.443$
0	100	100	100	100	100	100
1	84.2	58.4	92.8	64.3	52.2	58.4
2	71.0	34.0	85.9	41.1	31.0	34.0
3	60.2	20.0	79.7	26.4	19.9	20.0
4	51.2	11.8	73.9	17.0	13.6	11.8
5	43.8	7.0	68.5	10.9	9.6	7.0
7	32.3	2.5	58.9	4.5	5.3	2.5

* Whence we see the advantage of using a more penetrating radiation when the conditions of application are the same.

† The filtered x-radiation used at the present time for deep therapy is about twice as penetrating as the x-rays of this example, and less than one third as penetrating as the gamma radiation of radium when the filter is 2 mm. of brass.

doses are the same (3 cm.). The more penetrating radiation "wins out." This may be an advantage or a disadvantage according to the conditions.*

There are some limitations to the applicability of the results so far obtained which should be mentioned at this point. The most important is the effect of the scattered and secondary radiation on the tumor dose. The amount of radiation which reaches the tumor may be divided into two parts (1) that which travels in a straight line from the source to the tumor, and (2) that which reaches the tumor in a roundabout way. The latter is composed of (a) the radiation which is scattered, that is, deflected from its straight line path by the tissue surrounding the tumor, and (b) the secondary radiation which is set up in the tumor by the primary beam. The relative amounts of (1) and (2) depend on the depth of the tumor, the latter becoming more important as the depth increases. The method of measurement adopted for these experiments enables us to measure only the amount of the primary radiation which reaches a certain depth of tissue. The data thus obtained, therefore, enable us to calculate the *minimum* amount of radiation which reaches a given tumor under the conditions of application. The upper limit is obtained by neglecting the absorption of radiation by tissue and calculating the effect of distance alone. The actual radiation which reaches a certain depth of tissue is between these two limits. It can be determined by using a different experimental arrangement, which we hope to do in the near future.

Another limitation is imposed by the use of a metallic ionization chamber, as discussed in the first part of the paper. This, however, influences our results only when the quality of the radiation whose absorption we are measuring is changed appreciably in passing through the tissue used as the absorber. As this does not occur in the case of the penetrating radiation used in deep therapy, no error is introduced in using, for this purpose, the data here obtained. But it is not possible to use these absorption curves to determine accurately the beta ray dose for the skin from a knowledge of the gamma ray dose, or vice versa. For instance, if the ionization value of the bare emanation tube is 100%, and for a tube screened by 2 mm. of brass it is 6.7% (Figure 3, curve D), it is not correct to assume that, other conditions being the same, the time of exposure to produce the same superficial effect in the case of the screened tube would be $\frac{100}{6.7}$ or 15 times longer than in the case of the bare tube. The two have to be determined independently by physiological experimentation. The curves enable us to make a first approximation to the doses for various qualities of radiation; the correct values can be obtained by actual trial.

There is another point which requires further elucidation, that is, the significance of the ionization values given in the charts. A given quantity of radium emits radiation in all directions. The amount of radiant energy which passes through a surface of unit area perpendicular to the line of propagation represents the intensity of the radiation at this surface, independently of the quality of the radiation under consideration. But if we attempted to measure this intensity using ordinary ionization methods, the value we would obtain would depend to a great extent on the quality of the radiation. For instance, for beta rays, we could have an ionization chamber in which the gas would absorb all the radiation entering it, but for gamma rays only a fraction of the total radiation would be absorbed. In the latter case, then, we would not be measuring

* From the preceding discussion we see that, within certain limits, we can get the same amount of radiation at a given depth of tissue for the same skin dose by using radiation of distinctly different penetrating power, provided the distance of application is suitably chosen. Whether we would get the same physiological effect is a different matter, and one which cannot be determined by physical experiments alone. The question really is whether the physiological effect is independent of the quality of the radiation. At the present time this is not definitely known, but the scanty evidence available in the literature seems to support the conclusion that within certain limits it is independent of the quality.

the intensity of the radiation. To take the extreme case, if there were radiation which would not be absorbed at all by matter, then, however strong the source might be, we would never detect it by the means at our disposal, or, in fact, by any other means, if the law of conservation of energy is to hold. For this reason, when we are dealing with radiation of different qualities, and especially of different types, as the beta and gamma rays, we cannot speak of their relative intensities. Therefore the values on the charts are given in percentages of the total ionization produced when the emanation tube has no additional filtration, and they do not represent the intensity of radiation after passing through a filter or tissue or both, but the intensity of ionization which it produces. Accordingly it is not strictly correct to say that the radiation of an emanation tube is decreased from 100% to 6% by a filter of 2 mm. of brass plus 10 mm. of tissue. The radiation, considering the energy which is associated with it, is more than 6%, but this figure indicates the availability of its energy in affecting matter. For our purposes this is not a disadvantage, but an advantage. We are not concerned with the amount of radiation passing through tissue, but with the amount which is capable of influencing vital processes. When the quality of the radiation is not materially changed by the absorber, it is correct to say that the intensity of the radiation is decreased a certain percentage by the absorber. In such cases the factor of proportionality between the energy of the radiation and the amount absorbed remains the same. In addition to the effect of the material of the ionization chamber on the percentage values given for the different thicknesses of absorber, it should be borne in mind that the numerical values depend on the quality of the radiation which is taken as producing 100% ionization. This in turn depends on the wall thickness of the glass tube containing the emanation, which, however, does not affect the relative position of the curves.

In Table II, column 5, are given the coefficients of absorption for different metals and different tissues. Little need be added to what has already been said about the absorption by metals. The three coefficients given for lead indicate the change in the quality of the gamma radiation as the thickness of lead increases. In column 4 are shown the range of thicknesses for which the coefficients of absorption were determined. Column 6 shows the half value thickness, that is, the thickness of absorbing material needed to reduce the radiation to one half its initial value. The density (column 7) and the coefficient of absorption divided by the density (the so-called mass absorption coefficient, column 8) are given to show how the absorption varies with the density of the absorber. In column 9 are found the percentages of the radiation absorbed per millimeter of filter corresponding to the absorption coefficients given.

The values in the second part of the table were determined from the curves of Figures 3 and 4. They show the relative change in the absorption of radiation filtered through various thicknesses of lead and brass by beef muscle hardened in 10% formalin. It will be seen that from a filter of ½ mm. of brass to one of 3 mm. of lead the change is $\dfrac{0.0765-0.0709}{0.0765}=7.3\%$. The mass absorption coefficients have no special significance in this case, and they are not included in the table. It should be noted that the values in column 9 are given for one centimeter of tissue, and not for one millimeter, as in the case of metals.

The values in the third part of the table indicate the relative absorption of the radiation filtered through 1.92 mm. of brass by different tissues. For these experiments fresh organs were obtained. They were cut into as nearly parallel slices as possible, and absorption curves similar to those of Figures 3 and 4 were determined. The experimental work for fresh liver, spleen, muscle, brain, suet, and lung, as well as the formalined muscle, was done continuously, with the same emanation tube in the same position from

beginning to end. To make sure that the experimental conditions remained the same throughout, the absorption curve for pure gum rubber was determined at intervals, and used as a check. This also enabled us to include in the table some data obtained on previous occasions. The logarithms of the ionization values for different thicknesses of tissue were plotted to a very large scale and average straight lines drawn, as in the case of Figures 3 and 4. The coefficients of absorption were then determined by reading off two values from the straight lines.

From column 9 we see that the amount of radiation filtered through 1.92 mm. of brass which is absorbed by one centimeter of tissue is not very different for the different kinds of tissue. The two conspicuous exceptions are solid bone, which absorbs almost twice as much radiation as the average, and lung, which absorbs a little more than half as much as the average.

It is often assumed that the absorption of gamma rays is proportional to the density of the absorber. The table enables us to test the accuracy of this assumption. If the absorption were proportional to the density, then all the values in column 8 for the same quality of radiation would be the same. Evidently this is not the case. From physical experiments we know that the mass absorption coefficient (μ/ρ) is the same for substances which have essentially the same chemical composition. As this condition is practically fulfilled by all the soft tissues given in the table, we should expect the values of μ/ρ to be substantially the same. If we stop to analyze the results we find that, within the limits of experimental error this is the case. For lung tissue the value of μ/ρ is considerably lower than the average. The discrepancy, however, can be attributed to the numerous air spaces in this kind of tissue, which are included in the measurement of thickness, but are not included in the determination of the density, since they do not contribute to the volume of the piece of tissue measured by the amount of water displaced. The calculated density, consquently, was too high, and the mass absorption coefficient too low. The smaller difference in the value of μ/ρ for brain may be accounted for in the same way.

The explanation of the low value of μ/ρ for solid bone is based on the results of many physical experiments, which show that the mass absorption coefficient is lower for substances of medium atomic weight than for substances of very low or very high atomic weights.[9] Thus in Table II it is seen that the value for soft tissues, which have essentially the same composition and contain only elements of low atomic weight, are higher than for aluminum or brass, but lower than the first value for lead, which has a very high atomic weight. (The other values for lead are not comparable with the tissue values because the quality of the radiation in the two cases is quite different.) Solid bone, which contains considerable calcium, therefore, approaches aluminum in absorbing power, and for this reason the value of μ/ρ is lower than for soft tissues. "Porous bone," as used in this experiment, consisted of a bony structure having its interstices filled with soft tissue. Theoretically, then, the value of μ/ρ should be higher than for solid bone and lower than for soft tissue. Experimentally it is found that this is the case.

Considering the methods of determining the density of soft tissues, it is reasonable to conclude that, within the limits of experimental error, the mass absorption coefficients for soft tissues are equal. For practical purposes, therefore, we may say that in this case the absorption of gamma rays filtered by 1.92 mm. of brass is proportional to the density of the tissue. This is not the case when tissue is compared with aluminum and brass. For instance, if we know the coefficient of absorption for aluminum and we calculate its value for tissue of density 1.03, in the ratio of the densities, we get $\mu = 0.11 \times \frac{1.03}{2.74} = 0.0413$. But the value experimentally determined is 0.0694, which is 68% higher than the calculated value. On the other hand, the absorption of gamma rays by

tissue when calculated from the absorption by pure gum rubber, is correct for practical purposes. ($0.066 \times \frac{1.03}{.97} = 0.070$ instead of 0.069.) In the case of solid bone the absorption per centimeter is greater than for aluminum, in spite of the fact that the density of the latter (1.74) is considerably greater than the density of bone (2.01). In radiotherapy it is often assumed that the absorbing power of one centimeter of tissue is the same as that of one millimeter of aluminum. Probably this is true for x-rays of a certain quality, but it is very far from the truth in the case of gamma rays.

With the exception of solid bone the tissue which absorbs most radiation absorbs 7.5% per centimeter of thickness. Therefore, if in calculating the amount of radiation which reaches a certain depth, we take the value of

TABLE II

1 *Filter*	2 *Thickness mm.*	3 *Absorber*	4 *Range mm.*	5 *Coef. of Abs. cm.*$^{-1}$	6 H. V. T.* *cm.*	7 *Density*	8 μ/ρ *cm.*$^{-1}$	9 *% abs. per mm.*
Aluminum	6	Aluminum	6-22	0.11	6.3	2.74	0.0402	1.1
Brass	2	Brass	2-22	0.35	1.98	8.26	0.0424	3.5
Lead	2	Lead	2-5	1.01	0.686	11.34	0.0892	10.1
Lead	5	Lead	5-10	0.80	0.866	11.34	0.0705	8.0
Lead	10	Lead	10-15	0.66	1.05	11.34	0.0582	6.6
Lead	15	Lead	15-22	0.58	1.20	11.34	0.0511	5.8
								% abs. per cm.
Tissue	5.00	Formalin Beef Muscle	50-60	0.0815	8.50			8.2
Brass	0.48	Formalin Beef Muscle	10-70	0.0765	9.06			7.7
Brass	0.96	Formalin Beef Muscle	10-70	0.0755	9.18			7.6
Brass	1.92	Formalin Beef Muscle	10-70	0.0752	9.22	1.056	0.0713	7.5
Brass	3.04	Formalin Beef Muscle	10-70	0.0752	9.22			7.5
Lead	0.45	Formalin Beef Muscle	10-70	0.0752	9.22			7.5
Lead	1.0	Formalin Beef Muscle	10-70	0.0736	9.42			7.4
Lead	2.0	Formalin Beef Muscle	10-70	0.0726	9.54			7.3
Lead	3.0	Formalin Beef Muscle	10-70	0.0709	9.77			7.1
Brass	1.92	Solid Bone	3-20	0.13	5.5	2.01	0.063	13.
Brass	1.92	Porous Bone	20-100	0.075	9.3	1.15	0.065	7.5
Brass	1.92	Liver	20-90	0.074	9.4	1.06	0.070	7.4
Brass	1.92	Spleen	20-100	0.073	9.5	1.05	0.070	7.3
Brass	1.92	Muscle	20-100	0.069	10.0	1.03	0.067	6.9
Brass	1.92	Brain	20-100	0.066	10.6	1.03	0.064	6.6
Brass	1.92	Suet	20-100	0.065	10.7	0.94	0.069	6.5
Brass	1.92	Lung	20-70	0.045	15.5	0.78	0.057	4.5
Brass	1.92	Rubber	10-50	0.066	10.5	0.97	0.068	6.6
Brass	1.92	Formalin Beef	20-70	0.075	9.2	1.06	0.071	7.5

*Half Value Thickness

0.075 for the absorption coefficient, we are sure to be on the safe side. It will be seen also for deep radium therapy that the effect of intervening bones on the tumor dose must be small, because the actual thickness of solid bone is small in comparison to the thickness of soft tissues, and the absorption by porous bone is only slightly greater than that of soft tissues. This, however, is not true in the case of *x*-rays, and especially of soft *x*-rays. A convincing proof of this statement is afforded by *x*-ray photographs taken with soft and very hard rays. As for the absorption by human tissue compared to beef tissue, it may be said that in general the former absorbs a little less radiation than the latter. The difference, however, is practically negligible when the same kind of tissue or organ is considered in the two cases. One notable exception is fat, the absorption by human fat being considerably less than the absorption by suet. But in this case the densities are also quite different. The absorption by the fat under the human skin is about two thirds that of an equal layer of the skin proper.

SUMMARY

1. The apparatus used, consisting of a gold leaf electroscope and conical ionization chamber, and the experimental procedure are described in detail.

2. The most important limitations imposed by the experimental method adopted are discussed. They are due to:

(a) Use of a metal ionization chamber.

(b) Use of a gas as the absorbing medium in the ionization chamber.

(c) Exclusion of scattered and secondary radiation produced in tissue.

(d) Inability to reproduce in the physical laboratory physiological conditions.

3. The absorption curves for aluminum, brass, and lead are given. From these we see that:

(a) As the filter increases the transition from soft to hard radiation is quite sharp.

(b) Beyond a thickness of filter of a few millimeters in the case of aluminium and brass the absorption is exponential ($I = I_0 e^{-\mu d}$). In the case of lead it is not exponential in the range of thickness used.

(c) This shows that the filtration by a small thickness of metal is sufficient to give a radiation which is absorbed exponentially by metals of medium or low atomic weight. The radiation, however, is not strictly homogeneous, as indicated by the lead absorption curve.

4. The criterion for the quality of radiation to be used in deep therapy being the exponential absorption of the radiation by tissue, from Figures 3 and 4 we see that:

(a) A metal should be used as the primary filter.

(b) A secondary filter, composed of light elements like tissue, should be used to remove the soft, secondary radiation of the metal.

(c) There are different combinations of primary and secondary filters suitable for deep therapy.

(d) Beyond a certain point additional filtration, while increasing the penetrating power of the radiation slightly, decreases the intensity of the radiation considerably.

5. In deep therapy the limiting factor is the effect on the skin. Therefore it is important to know what fraction of the skin radiation reaches a given depth of tissue. The value of this fraction can be varied within limits by varying the distance of the applicator from the skin, or the filtration.

(a) An example is worked out to show that in the case of gamma rays it is more economical to increase the percentage of the skin radiation which reaches a deep tumor by increasing the distance of the applicator than by increasing the filtration.

(b) A second example shows that, using two sources of radiation of distinctly different penetrating power, we can get the same percentage of a skin dose at a certain depth of tissue in either case by choosing the distance of application properly.

(c) Table I shows that when the distance of the applicator is large in comparison to the tumor depth, the penerating power of the radiation has the greater influence on the tumor dose. (This is the case of x-rays.) On the other hand, when the distance of application is about the same as the tumor depth, and the radiation is very penetrating, the distance has the greater influence on the tumor dose. (This is the case of radium therapy.)

(d) The table shows, also, that when the distances are adjusted so as to get the same skin dose and the same dose at a depth of three centimeters, using radiation of different degrees of hardness, the doses are not the same at any other tissue depth, and especially at greater depths than the one for which the doses are the same.

6. The coefficient of absorption is the important factor which identifies radiation. The numerical value depends on the quality of the radiation and on the nature of the absorber. From Table II we see that:

(a) When the same tissue is used as an absorber and the filtration of radium rays is varied in steps from 0.48 mm. of brass to 3 mm. of lead, the coefficient of absorption gradually decreases from 0.0765 to 0.0709. But while the penetrating power of the radiation is increased 7.3% by the additional filtration, the available radiation is decreased 65%.

(b) The same radiation (1.92 mm. brass filter) is absorbed to a different extent by different tissues. For soft tissues the coefficient of absorption is proportional to the density of the tissue.

(c) The absorption by tissue from different organs (except lung tissue, fat, and solid bone) is nearly the same. Therefore if we take 0.075 for the value of the coefficient of absorption of gamma radiation filtered through 1.92 mm. of brass, we are sure to be on the safe side in any calculation we may make for practical use. Corresponding to this value of the absorption coefficient, the thickness of tissue necessary to absorb one half of the radiation is 9¼ centimeters. As a round figure, easy to remember, we may take the half value thickness of human muscle tissue for gamma rays to be ten centimeters.

(d) The presence of bone in the path of the radiation is of no great consequence in regard to the amount of gamma radiation which reaches the tumor beyond it. The only part of the bone which absorbs considerably more than muscle is the solid part. But in any practical case this makes up a small fraction of the total thickness traversed by the radiation. In the case of x-rays bone plays a more important part.

7. The results obtained from the experiments described in this paper can be used for the solution of problems in radium therapy, subject to the following limitations:

(a) The calculated amount of radiation reaching any given tissue depth is always the *minimum* amount which will reach this depth under the conditions of application.

(b) Skin doses of beta and gamma radiation are not to be compared according to the ionization values given in Figures 3 and 4. They must be determined independently by physiological experiments.

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PERSONAL EXPERIENCE WITH THE APPLICATION OF THE NEWER ROENTGEN THERAPY IN CANCER*

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The ideal that every therapy attempts to attain is a complete inhibition and neutralization of the disease, and if possible the maintenance of normal function. Unfortunately excision of a cancer does not prevent further invasion, nor immunize against it, nor does it maintain the functions of the tissue affected. So it is easily conceivable why radiotherapy, even with our former limited knowledge, played such an important part in the treatment of cancer. The fact that recent advances in the technique of radiotherapy have been accomplished abroad makes it apparent that the older methods were found wanting. It is almost needless to say that insufficient penetration of hard rays to the deeper tissues was one of the shortcomings; another was the lack of measurements for practical purposes, and also the lack of knowledge of the exact dosage necessary to influence a carcinoma, a sarcoma or ovary.

Some of these obstacles were overcome by the construction of more powerful apparatus, and also tubes to tolerate higher intensities. The electroscope and iontoquantimeter furnished means of measurement for practical purposes, and with these, the determination of dosage for the destruction of carcinoma and sarcoma were made possible. Apparatus, tubes and technique have been described elsewhere, and need not be mentioned here.

The application of the newer methods of roentgen therapy has led to more gratifying results in the treatment of cancer. Since my return from abroad in the middle of September, owing to the delay in shipping the German apparatus, this improved technique as far as it is applicable to my own apparatus, has been made use of. The following case report is, of course, a preliminary one, and only one of a type has been selected.

One of the first cases selected for this newer therapy was a patient with an inoperable carcinoma of the cervix. She had received a radium treatment three and a half months previous, with no evident arrest of the disease. The malignant process continued, so that when she first came to me, her hemoglobin was 40 per cent, and to all appearances, she was in a beginning state of cachexia. Desirous of trying out the newer technique, she was subjected to the following treatment: a two hour radiation dose on four consecutive days was administered, instead of one session of eight hours, as in Bumm's Clinic. The focal distance used was 50 cm., and the portals of entry 15 by 18 cm. The rays were filtered through 0.5 mm. of zinc, plus 1 mm. of aluminum. In addition 50 mg. of radium element were introduced into the cervix and left there for fifty hours. My aim was to administer what the Germans call a full cancer dose at one session. The reaction was not as severe as those I

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saw in Germany when the entire treatment was given in one day. The patient gained five pounds in weight within the first week, pain disappeared entirely, and she is at present going about, engaged in her usual activities, free from any clinical manifestations of the disease. A month ago examination of the cervix showed it to be entirely fibrosed.

Another patient was referred for radiation for recurrent carcinoma in the axilla after radical excision of a carcinoma of the breast. Female, sixty years old, was operated upon for carcinoma of the breast a year and a half ago. Six months later a tumor recurred in the axilla; it was removed again, only to recur within the year. The recurrence, when she reported to me, was the size of half an orange, it was a fluctuating mass of broken-down, necrotic tissue. She suffered much pain, and had to be constantly under the influence of opiates. All in all, she was in pretty bad shape. She also received four radiation doses of two hours each on consecutive days. A dose was directed from front of axilla, one posteriorly into axilla, one from above the shoulder joint, and one from below into the axilla. The focal distance was 50 cm., the filter zinc plus aluminum, and the portals of entry 15 by 18 cm. Four days after completion of the roentgen treatment, 3,000 mg. hours of radium element were placed in the axilla over four areas. A week later the tumor had disappeared entirely, she was free from discomfort, and had left off all narcotics.

In another patient a carcinoma of the breast had recurred over the anterior region of the sternum. The patient was operated upon two and a half years ago for carcinoma of the breast at Mt. Sinai Hospital, had a stormy convalescence, developed erysipelas with abscesses, and had to stay in the hospital for three months. In October last a recurrence of about 12 by 15 cm., the size of the palm of my hand, developed over the sternum extending to the anterior axillary border. Two radiation doses of four hours each, with 70 cm. focal distances, portals of entry 15 by 18 cm., zinc and aluminum filters, were administered. A week later the tumor had receded by half, and in another week the entire tumefaction had disappeared. In this case, about seven weeks ago, a tumor the size of a large lemon made its appearance in the other breast. The surgeon again referred her for radiation, considering her a bad risk for surgical intervention. A full cancer radiation dose was administered, and the tumor has since receded.

These reports are of course only preliminary; the end results may be such, perhaps, as to cause a modification. Furthermore the response in all cases may not be as striking as in these. It is obvious, however, that more intensive radiation than heretofore must be administered along the lines of modern technique. The dosage in this newer technique comprises a more thorough understanding of the biological and physical properties of the rays as they are emitted from the tube, and of the accompanying secondary radiation. The quality of ray, in particular, is one of the most important factors, and of equal importance are the substance and amount of filtration used, the focal distance, and the size of the portals of entry. The proportionate relationship between the radiation energy at the surface of the body, and that of the lesion in the deeper tissues, is called the dosage quotient. This dosage will be most favorably effective in the deeper tissues when we increase the distance of the radiation source, notwithstanding the fact that an increase in the focal distance necessarily increases the time of obtaining a skin erythema dose.

It is well known that with 0.5 or 1 mm. of copper or zinc as a filter, a considerable amount of the energy emitted from the tube is lost. This loss is more than compensated for by the fact that radiation through 0.5 or 1 mm. of copper or zinc produces a more favorable absorption coefficient. In other words rays from this point on will show very little qualitative change, and additional filtration would serve no further purpose.

In addition to the primary rays, the scattered secondary rays materially aid the

dosage quotient. For instance, it has been worked out by Friedrich and others, that with 50 cm. focal distance, and a 10 mm. aluminum filter, the primary radiation energy under 6 cm. of tissue would be 22 per cent that of the surface dose; in reality, though, it is increased to 51 per cent by the scattered secondary rays.

CHART I

Filter	*Focal Distance*	*Depth under Surface*	*Estimated Primary Dosage %*	*Actual % with Secondary Rays*
10 mm. Alum.	50 cm.	6 cm.	22. %	51. %
"	50 cm.	8 cm.	13.8%	42. %
"	50 cm.	10 cm.	8.4%	31. %
1 mm. Copper	50 cm.	6 cm.	25. %	67.5%
"	50 cm.	8 cm.	17. %	54. %
"	50 cm.	10 cm.	10. %	44. %

Aside from this increase in the amount of radiation available in the deeper tissues through the proper filtration, the size of the portals of entry must be given consideration. For example, under 10 cm. of tissue, with a portal of entry of 1.5 by 2 cm., the dose is 9 per cent of that received on the surface; with a portal of 6 by 8 cm., however, the amount is increased to 28 per cent, and with portals of 10 by 15 cm., to 35 per cent, and so on. In other words, the larger the portal of entry, the more favorable is the dosage quotient, up to a point of 20 by 20 cm. Any increase in size over this seems to bring no appreciable gain; that is, the intensity of the ray diminishes by dispersion the smaller the portal of entry, and increases in percentage the larger the portal of entry.

CHART II

Dosage Quotient in the Deeper Tissue
(Focal Distance 50 cm.)

Portal of Entry	*Under 10 cm. Tissue*	*Under 3 cm. Tissue*
1.5 x 2 cm.	9%	47%
6 x 8 cm.	28%	66%
10 x 15 cm.	35%	77%

Chaoul, of Sauerbruch's Clinic in Munich, has adopted a very ingenious device of wax blocks, which he calls a "ray concentrator." One set is arranged on either side of the tube, and another at each side of the radiated field, taking in the entire distance between the skin and the tube. In this way he collects or concentrates the rays of dispersion which are then deflected to the center of the field, and thus increases the radiation quotient from 40 to 60 per cent. It becomes essential therefore in order to reach the tumor with the most favorable and suitable dosage quotient, to increase the focal distance, to use filtration of at least 0.5 mm. of copper or zinc, and lastly to use as large a portal of entry as the conditions permit.

Opitz of Freiburg has taken advantage of all these factors which increase the dosage quotient, in the treatment of carcinoma of the uterus, first, by using a focal distance of 50 cm., and second, by enlarging the portal to its maximum of 20 by 20 cm., and by using 1 mm. of copper as a filter. In this manner a skin erythema dose requires about two hours, one application is administered from the abdomen, one from the back, and two from the side. Here also a minor detail of refinement is made use of: the anterior dose is administered so that the centralized ray strikes the left edge of the tumor slightly obliquely, and the posterior dose the right edge of the tumor, in order to prevent damage to the rectum, which is anatomically situated to the left. The sum total of the rays reaching the cancer mass in this manner is very nearly a full cancer dose. To guard against a sublethal dose to the interior of the tumor, a small dose of radium is placed in the uterus. Even if the cancer itself receives slightly more than a knockout dose, the healthy adjacent tissue tolerates this and thus escapes damage.

CHART III

Dosage Quotient under Three cm. of Tissue

Portal of Entry	*Focal Distance*	*%*
9 x 12 cm.	30 cm.	74%
10 x 15 cm.	50 cm.	86%
9 x 12 cm.	50 cm.	86%
15 x 15 cm.	80 cm.	90%
9 x 12 cm.	100 cm.	90%
10 x 15 cm.	100 cm.	93%

That intensive radiation for short periods is much more effective than smaller doses for longer periods is pretty generally conceded, and practical use is made of these pathological and biological findings. It holds true also, with small doses frequently repeated, that the period of latency is considerably protracted, and furthermore a cumulative effect may be experienced producing chronic changes which are not at all desirable, either by stimulating the growth itself, or by damaging the healthy tissue. Great stress is laid upon the advisability of administering the entire lethal dose at one sitting. There are, however, times when the entire dose cannot be administered in one day. The condition of the patient or the danger of absorption toxemia may not admit of this. At any rate all efforts should be directed to administering a full lethal dose within a week.

By way of summary I would like to draw special attention to the following points:

It is most essential that sufficient intensive roentgen or radium rays be administered to knock out completely all parts of the cancer without damaging or destroying adjacent healthy tissue. If any one part of the tumor receives a sublethal dose, failure and recurrence is sure to follow.

To effect the most favorable conditions of radiation to the deeper tissues, proper filtration, increase in the focal distance, and increase in the size of the portals of entry must be made use of.

The determination of correct dosage comprises knowledge of the clinical location of the tumor, its pathology, radiation dosage quotient, and absorption coefficient.

From the personal application of this technique in this short period of time, I gain the impression that raying in the form of a complete knockout dose administered at one time will bring about better results in cancer therapy.

CLINICAL RESULTS FROM THE NEWER TECHNIQUE OF DEEP ROENTGENTHERAPY IN MALIGNANT DISEASES

By GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

DURING September, 1920, Drs. Coolidge and Schmitz brought back to us from Germany the information that in Germany a greater amount of filtration was being used in the treatment of deep-seated malignant disease, with the source of rays at a greater distance from the skin and with the use of a higher voltage. The impression of the few men who had the privilege of visiting the German clinics was that more satisfactory results were obtained from this technique than from the lighter technique used in this country. Our equipment in America did not permit an exact duplication of the technique used in Germany because our apparatus as built to-day will not generate current at a voltage greater than 125,000, or at most 130,000. It seemed important, therefore, to see whether the technique could be improved with our present apparatus and then perhaps later to determine whether the results obtained by such improvement would correspond to the results obtained in Germany. It is always desirable to proceed from the known to the unknown, and instead of jumping wildly from one technique into another of unknown quantity and unknown value, I proceeded by calculations to transform my former technique for deep roentgentherapy into my present technique. Generally my former technique consisted of 5 milliamperes of current at 126,000 volts, at a focal skin distance of 20 cm. filtered through 6 millimeters of aluminum, for a period of 8 minutes. My present technique consists of the use of 5 milliamperes at 126,000 volts, filtered through 10 millimeters of aluminum or glass, at a focal skin distance of 30 cm., for a period of forty to fifty minutes. I find that forty minutes will rarely give an erythema, and that fifty minutes will generally give an erythema. This technique has been developed gradually, in part by calculations and in part by experimentation.

I would like to add a caution at the beginning of this article and repeat it again at the end: it is most important in every instance before the current is turned on that the filters be counted to make sure they are in place, because if filtration is deficient this prolonged treatment will produce an incurable burn. As a precaution against an accident I require that two people make observations on the filters for every dose given. If the equipment is arranged for deep treatment only, so that this one uniform technique is used continually for all kinds of cases, then the filters can be permanently put in place and the precaution of counting will not be necessary, but in the general roentgenological laboratory the apparatus must be used for different purposes and 10 millimeters of filter is not always desirable, because it wastes energy unnecessarily.

RELATIVE VALUE OF FILTERS

In order that our technique be made understandable it is necessary to know the relative value of various filters. Several years ago, at one of these midwinter meetings of this Society, I recommended the use of glass instead of aluminum because the metal filters frequently led to puncture of the Coolidge tubes. From a scale furnished by the Radium Chemical Company of Pittsburgh, I observed that glass had approximately the same filter value as aluminum. Therefore by using glass we obtained a filter less likely to lead

Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

to punctures of the tubes and that serves equally well for filters. For this purpose the ordinary glass used for photographic negatives was cut to the proper size. First of all we made a direct comparison of many layers of this glass and in our own laboratory found it to be uniform. I am told by Professor Shearer that glass is not uniform in its density, and therefore I caution others against the use of glass until it has been compared carefully with aluminum or some other standard, after which I believe that it can be used safely. For this purpose we took 10 millimeters of aluminum and 10 millimeters of glass and with the current such as is used for treatment above described we were able to prove that, at least so far as the photographic values are concerned, the two are equal. The exposures were made of ⅛, ¼, ½, ¾ and 1 second. In order to form some idea of the relative value of filters such as are used in Germany I then made a comparison photographically of copper and aluminum. In Germany, as you will recall, they are using from ½ to 1 millimeter of copper as a filter. By my experiments I learn that ½ millimeter of copper is equal to 13 millimeters of aluminum measured photographically.

With the above technique and with exposures lasting from forty to fifty minutes (and in a few cases I have given sixty minutes), it is self-evident that it is undesirable from every standpoint to limit our field of radiation to small areas such as we have been doing in the past. I think most of us have gradually increased the size of the field of exposure. When we consider that the smaller the field of radiation, the less the amount of secondary radiation, and since we must acknowledge that the secondary radiation probably does as much as the primary radiation towards destroying malignant disease, and in fact may be the sole cause of destruction of the malignant cells, the relative value of small areas and much cross-firing decreases. It is always desirable to cross-fire as much as possible providing we are actually cross-firing, but mere division of the surface of the body into small areas, as I have often seen done, does not actually increase the cross-fire value. For example, in the treatment of carcinoma of the uterus, it is my practice to treat the local disease directly by radium and then to cross-fire through an area extending from the symphysis pubis to the umbilicus and to the anterior superior spines on each side, and either use this as one area for treatment or divide it into two. Then a similar dose is given through each lateral surface of the pelvis and one or two similar areas posteriorly. In this way all parts of the pelvis are irradiated and I have seen some most brilliant results. For example, a patient referred to me on September 30, 1920, by Dr. Wm. R. Nicholson, was considered by him totally inoperable. The entire cervix, including the walls of the upper part of the vagina, were involved by the carcinoma, making a total area of malignant disease 7 or 8 cm. in diameter. She received 4200 milligram hours of radium treatment locally and two courses of *x*-ray treatment consisting of four areas in each course during six weeks. At the end of two and a half months all evidence of disease had disappeared. Even in recurrent disease about the pelvis, with the above technique I have obtained results that I have never seen equalled by my former technique. In recurrent and metastatic disease of the breast and in primary disease of the breast I have seen results which are far superior to those obtained by my former technique. In a few primary cases that for some reason were considered inoperable, I have seen all palpable evidence of malignant disease of the breast including recurrent and metastatic nodules, disappear more rapidly and more satisfactorily than formerly. I have also seen recurrent nodules disappear that gave no response to the technique formerly used.

I think all of us have made the observation in the treatment of malignant disease that unless a pronounced primary effect is obtained and the disease made to disappear within a few months, it often develops a resistance which is as great as that of the

surrounding tissues, and therefore it requires an amount of treatment necessary to destroy the malignant disease such as will also destroy the surrounding healthy tissue. I believe, therefore, that it is desirable in all instances to get as much treatment into the malignant disease within the first month or two as can be borne by the healthy tissues, and in this way the malignant disease is destroyed while it is yet more sensitive to radiation than the healthy tissue. For this reason I dislike treating a patient who has been inefficiently treated for several months and then referred to me because the disease has made progress.

Another phase of this newer deep roentgen therapy that cannot be ignored refers to the radiation sickness. Those who give small and frequent doses are less concerned about the radiation sickness. There is, however, nothing magical in anyone's technique with regard to radiation sickness. It is probably a measure of the amount of radiation and the reaction of the tissues and the nervous system therefrom. Those who give little radiation will therefore have little radiation sickness. We immediately found, therefore, that as we increased the length of our exposures we also increased the radiation sickness, both in frequency and degree. We are hoping, by careful study of the subject, to learn how to overcome this condition; but for the present an increase of the interval between the treatments or doses given has been found to be our best safeguard. One cannot, however, I believe, obtain the same results by too much division of dosage; and if we use this deeper technique and at the same time attempt to give it in fractional doses, the expense thereof will be correspondingly increased, and unless most carefully managed may allow the cancer cells to mature and develop a greater resistance to the rays. As it is, the expense of giving a dose of the deeper therapy is greatly increased as compared with the former technique. One must, therefore, keep the practical side in mind until more powerful equipment is developed and some means found of reducing the expense due not so much to apparatus, electricity, etc., as to human service.

With increase in the length of exposure one also encounters the increased danger of stray radiation and secondary radiation. Therefore greater precautions are necessary to guard against leaking tube shields, or any other form of stray radiation. As a step in this direction, I have designed the protecting device previously described.[1] If more powerful apparatus is developed we must also keep in mind that with increased power comes increased danger, which necessarily calls for increased precautions.

I believe the technique above described to be a definite advance. It will probably be further modified and further developed, but so far it is adaptable to our present outfits, and if used with great caution greater beneficial results can be obtained. I think we may draw the following conclusions at present:

1. Increased filtration, with increased focal skin distance, will increase the value of deep radiation as compared to the surface effect.

2. By increasing the above two factors the time of radiation is greatly increased—probably five-fold. This prolonged radiation in itself may be an important factor in preventing cell division and regeneration of the cancer cells.

3. Radiation sickness is increased, and extra effort must be made to overcome this effect.

4. The greatest caution must be observed in keeping the filters in place and at their full prescribed quantity.

5. Increased protection is necessary for both the patient and the operator.

6. The clinical results obtained from this new deeper technique excel those obtained formerly.

[1] A New Device for Increasing the Protection of Both the Patient and the Roentgenologist. Presented before the Philadelphia Roentgen Society January 13, 1921, and THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 29, 1921.

A NEW DEVICE FOR INCREASING THE PROTECTION OF BOTH THE PATIENT AND THE ROENTGENOLOGIST*

By GEORGE E. PFAHLER, M.D.

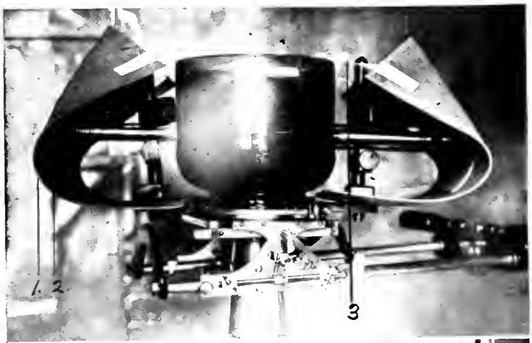
PHILADELPHIA, PENNSYLVANIA

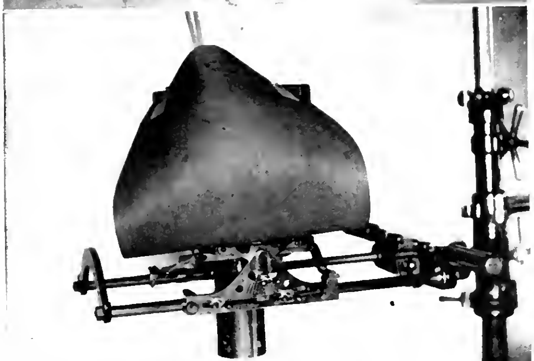
WITH the increase of power in our exciting apparatus there has been a progressive increase in dangers to both the patient and the roentgenologist. These dangers consist primarily of injuries from the high tension current to either patient or roentgenologist, and secondarily and more insidiously the dangers from stray radiation. With the death of one physician and two patients during the past two years from accidental contact with the high tension circuit it is incumbent upon us to utilize every means possible to eliminate such possibilities; and while the device which is here described briefly and illustrated more particularly may not give absolute security, it surely does give increased protection. It is important to see, of course, that there are no loose wires or any that are likely to become loose; but there still remains the possibility that during an examination a patient may bring some part of his body within sparking distance of the high tension current, and we know that when the arc once starts through the air, which ordinarily is an insulator, but which then becomes a conductor, a large amount of current can easily flow into the patient, and the results above referred to indicate the danger.

The danger from stray radiation to both the patient and the operator has increased with the increased voltage and filtration. While these stray rays are never as strong as those applied directly to the part being treated, as we increase the time of exposure (which increases with the amount of filtration), any escape of stray rays through the opening in the glass shields becomes a serious danger to both patient and roentgenologist; and while the roentgenologist is farther away than the patient, he is exposed to these stray rays over so much longer period of time that they become a danger to him. For instance, most of us who are now using 5 milliamperes of current and 9 inch parallel spark gap, can give an erythema dose of unfiltered rays in approximately one minute at a distance of 8 inches. With increased filtration to 10 millimeters of aluminum and increased distance to 12 inches the time is increased to as much as fifty minutes and therefore, even though only one-tenth or one-hundredth as much radiation comes through the opening in the glass bowl as is passed through the opening in the diaphragm, it becomes a serious danger to both the patient and the operator.

As a step towards overcoming these dangers above described, I have made use of opaque rubber which contains approximately 25 per cent of lead and which has an insulating value equivalent to a 4 inch spark. That is, it will force a spark to leap around the edge for a distance of 12 inches before puncturing the rubber. But since the distance from the terminal of the tube to the top of the rubber is only 8 inches the actual insulation value is only about 4 inches, because the current tends to creep along the rubber to about one half the air spark resistance. The rubber is about 3 millimeters thick, and is sold as Hercules red rubber packing. A piece of this rubber, 12 inches by 18 inches, is attached to the base of the diaphragm and is then curved over the ends

*Read at the Philadelphia Roentgen Society, January 13, 1921, and at the Midwinter Meeting of the Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 28, 29, 1921.





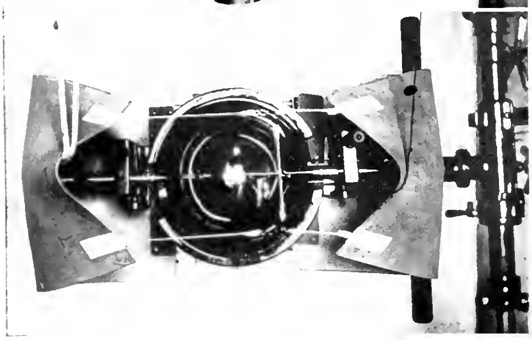


Fig. A (*above*). Lateral View, showing the opaque lead rubber curved about the ends of the tube and closing off the line of radiation through the openings in the tube. (1) The opaque rubber. (2) Reinforcement layer. (3) Springs and hooks holding the top of the lead rubber together across the top of the lead glass shield.

Fig. B (*middle*). Front view of protective shield.

Fig. C (*below*). Top view of protective shield.

of the tubes and the wires, and is folded back towards the glass bowl so as to cover both the front and the back and at the same time to carry the wires upward 8 inches. The central portion of this rubber directly in front of the terminals of the tube is reinforced by another thickness of this rubber, 6 inches by 6 inches, which increases the insulation and increases the protection against the roentgen ray. The upper ends of this rubber are fastened together by cords and small hooks so that they can be easily released when it is necessary to change the tube. The changing of tubes is fortunately not so frequent as was necessary with the old type of gas tube, and therefore the inconvenience of making these connections is of secondary importance. This rubber protection can be adapted to any type of tube holder. At least, we have adapted it to six different types used in our laboratory and while I am only illustrating one, a little ingenuity on the part of the roentgenologist or a mechanic will enable him to adapt the device to anyone's use. The photographs have been made in three different views and I think illustrate the attachment and application better than I can do by description. On one tube stand we have found an advantage in extending the cords over a cross-piece resting on two posts which fit over the rim of the glass bowl or shield. This carries the support higher and makes the tension less upon the terminals of the tube.

This protecting device moves easily with the tube holder and glass shield and is no inconvenience. While it does not give absolute protection either against the high tension electric current, or the radiation, it is a good step in the right direction.

X-RAY TREATMENT OF PULMONARY TUBERCULOSIS*

By WILL WILKINSON, M.D.

PHOENIX, ARIZONA

FOR the past decade *x*-ray men have been the cavalry of the great and splendid army of medical men, and I appreciate the honor of being made a member of a society all of whom are imbued with the "let's go" spirit.

It occurred to me that in one respect I am treading in the path of my illustrious confrère and fellow-townsman, Dr. Warner Watkins, who usually starts something whenever he appears before you. It is a little surprising that *x*-ray therapy is a recognized treatment for glandular, bone, skin and peritoneal tuberculosis, but has been so little applied in chronic lung trouble. The substernal lymph glands are usually the primary foci of infection, and the arrest of the disease is complete or partial in proportion to the fibrosis and calcification of chest lymph glands. Careful workers have very generally reported success in the treatment of tuberculous cervical glands. Why not give tuberculous bronchial glands the same treatment?

The proven value of the *x*-rays in unresolved pneumonia has established its place in the treatment of this disease of the chest. Furthermore, it is admitted that it is the actinic rays of the sun that are responsible for the brilliant results of solar therapy in all forms of tuberculous infection. Also we now know that the sun's rays are physically the same as *x*-rays, only much softer. I believe the greater penetration of *x*-rays makes them especially valuable in the treatment of deep-seated tuberculous foci in the lungs, and that we are really putting sunshine inside the chest.

Dr. J. D. Gibson, of Denver, was one of the pioneers in *x*-ray therapy; he gives this remedy the foremost place in the complete arrest of his own lung disease some twenty years ago. Since that time he has had a very large clinical experience with *x*-rays in office treatment of consumptives. After being in general practice in Phoenix, where about half my work was with tuberculous patients, I had the opportunity of visiting Dr. Gibson. He showed me a large number of chest plates of his patients, and, with few exceptions, the cases that persisted in the treatment showed marked reduction in the substernal gland shadows. As I went over his case records and interviewed his patients, I was convinced that they improved in appetite, weight and strength much more rapidly than my own tuberculous patients, or those of any practitioner with whose work I was familiar.

In a recent article, Dr. Gibson says: "The fact is, the *x*-ray is probably the greatest blessing ever bestowed in one agent upon suffering humanity through the medical profession. *X*-ray diagnosis has saved its thousands, but radiotherapy when properly recognized will save its millions. It has a range of therapeutic effect from producing the gentle stimulation with slight hyperemia, on to over-stimulation and inhibition, until destruction of tissues results."

Again, from the same paper: "I made the claim many years ago that the opsonic index should be controlled and regulated by means of the *x*-ray. Dr. Crane, of Kalamazoo, and Dr. McCullough, of London, have sustained this contention. Later, I ascertained that with the hyperemia and engorgement produced in tissues by means of the *x*-ray, changes developed in the tissues which had for their final effect the creation of homologous vaccine from the antigens developed within the patients' own tissues. These vaccines, antitoxins and antibodies, generated in Nature's own way, give us a most ideal autogenous vaccine."

Other writers have called attention to the

*Read before the joint meeting of the Pacific Coast Roentgen Ray Society and the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY, at Avalon, Catalina Island, California, June 19, 1920.

improvement in lung trouble when only the cervical glands were being rayed, and attributed the benefit to autogenous vaccination from the cervical glands. Dr. Gibson gives a series of blood counts made on a number of cases which show a decided increase in the mononuclear cells.

A very interesting paper, entitled "Experimental Studies with Small Doses of X-Ray," appeared in the *Lancet* of April 26, 1919. Dr. Russ and his coworkers studied their effects upon the blood and found the mononuclears more markedly affected than the reds or polynuclears. I quote at some length his results:

"We have obtained identical results upon the lymphocytes with unscreened medium x-rays and with very hard rays screened by 7 mm. of aluminum.

"From the results of many experiments devised to determine the nature of the action of the x-rays on the lymphocytes, it has been concluded that the action is a direct one upon these cells in circulation. One such experiment was as follows:

"A rat completely screened by lead except for a region over the heart, was exposed to a parallel beam of x-rays: the exposure was adjusted so that the circulating blood should receive the same amount of x-rays as it would by exposing the whole animal for about one minute. The fall and recovery curves of the lymphocytes were obtained and charted. They were nearly identical.

"The fact that the lymphocytes disappear from the circulation in such large numbers after an exposure lasting but two seconds leads us to doubt very strongly that this is due to their destruction, especially as they reappear with great rapidity. It is not a direct local effect of the radiation upon the tissues, for no local accumulation occurs in the irradiated area, nor have we detected any alteration in the general distribution of the lymphocytes through the lungs, liver or kidneys, as they have been examined from this point of view.

"If lymphocytes *in vitro* be given a dose one thousand times as large as that required for these effects *in vivo*, no degenerative changes are detectable microscopically and no diminution in their numbers is observed.

"A rat, when given a small dose of x-rays (twelve seconds) shows a 50 per cent reduction of its circulating lymphocytes one hour later; then it begins to recover and in twenty-four or forty-eight hours is normal again. If the same dose is administered a fortnight later, a similar drop occurs, the recovery is slightly delayed, but the numbers of lymphocytes finally reached is generally greater than at the beginning. Repeated application of such a small dose may result in a high degree of lymphocytosis. The circulating lymphocytes in the two cases depicted have increased from 11,000 and 25,000 to 112,000 and 117,000 per cm. respectively; corresponding counts for the polynuclear leucocytes were initially 5,000 and 5,000, terminating in 10,000 and 14,000 per cm. respectively.

"There is clear evidence of instability in the blood contents of these irradiated animals, but the number of lymphocytes rarely drops so low as the normal level, even several months after the exposures have ceased.

"Exactly what are the best radiation conditions for the production of this lymphocytosis it is not yet possible to say. Large doses may eventually produce the condition, but are to be avoided, owing to their injurious nature. It is uncertain, at present, whether a small dose repeated at very short intervals produces the result. One batch of eleven animals was given small daily doses (twelve seconds) over a period of two months. The average of the lymphocyte counts before irradiation was 19,000; three days after the last dose of x-rays, it was 27,000, and no marked rise was detected later, although counts were made upon some of the animals for another two months.

"It has been shown in a previous publication by two of us that when sarcoma cells (Jensen's rat sarcoma) are inoculated into rats which had been previously immunized, the failure of the sarcoma to grow is associated with some special activity on the part of the lymphocytes.

"The further experimental fact acquired

was that if immune rats were given a dose of x-rays sufficiently large to cause and maintain a marked lymphopenia, then such immune animals became once more susceptible to the growth of the sarcoma."

X-ray workers have become sterile, and we are able to induce the menopause and sterility in women, whenever indicated. It may be that the reproductive power of the tubercle bacillus is reduced by the Gibson method of x-ray treatment and its virulence destroyed.

During the past seven years, I have been treating consumptives with x-rays and most of them were decidedly benefited. I have also had a good success in relieving winter coughs which would not respond to cough mixtures. Three to six exposures on alternate days are usually sufficient in these cases.

As an illustration, I cite the case of a young mining engineer who for four years after coming to Arizona did not improve greatly and was unable to work. In the fall of 1913, I gave him a three months' course of x-ray treatment. There was marked improvement in cough, and pulse dropped to eighty; by early spring he went to work and has not lost much time since. Last fall and winter he took another course of treatment, of five months' duration, with decided benefit in his general condition. The radiographs of his chest showed marked increase in peribronchial fibrosis, with scattered areas of calcification and diminution in the width of the hilus shadow.

TECHNIQUE

We give treatments three times a week, alternately exposing the anterior and the posterior chest, using 2 to 3 ma., 6 in. spark, 15 in. distance, 5 to 10 minutes time, and 3 mm. of aluminum as filter. In many cases, we begin with a dose somewhat less than the above, especially if the case has rapid heart and slight temperature, applying the lesson taught by heliotherapy, that the tuberculous patient must begin with very short sun baths.

To sum up, we believe that when x-ray therapy is properly used in incipient tuberculosis, especially with those who have improved or are at a standstill, most of them will be decidedly benefited. As in pneumonia, inflammation and congestion are relieved, adhesions are absorbed to some extent, lymphocytes are increased, infected lymph glands become shriveled and cease to be foci of infection. Fibrosis and calcification are promoted, the pulse rate is lowered, and the blood pressure approaches normal. With the improved circulation and elimination, patients sleep and eat better and gain in weight. Expectoration becomes at first freer and then thinner and gradually decreases. The cases progress toward complete arrest much more rapidly than they would without the x-ray therapy.

Later, we hope to be able to report a series of cases with blood and x-ray findings before, during and after courses of x-ray treatments.

[NOTE. The technique we are now using is 5 ma., 9 s. g., 15 in Tg. Sk. and 3 to 6 minutes time, according to temperature reaction of patient. We do not want more of a reaction than that of a light vaccination. This dose is given two or three times a week, alternately anteriorly and posteriorly.]

A ROENTGEN STUDY OF DUST INHALATION IN THE GRANITE INDUSTRY*

By D. C. JARVIS, M.D.

BARRE, VERMONT

BARRE, Vermont, being the largest granite center in the world, the opportunity to study granite dust inhalation is exceptional. A permanent residence in Barre rules out the time factor and makes it possible to carry the work to any conclusion thought advisable. Practicing eye, ear, nose and throat for the past twelve years among granite cutters, one's attention could not fail to be focused sooner or later on their respiratory troubles, and becoming interested in the problem a hospital transformer was purchased in 1917 for office use in the hope that with its assistance some knowledge might be gained of the chest condition of these men.

INTRODUCTION

The accumulation of cases was slow and the advent of The National Tuberculosis Association in the field during 1919 was welcomed. Through its Committee on Mortality from Tuberculosis in the Dusty Trades, an investigation of the granite industry was started, because it was thought that the granite industry of all the dusty trades would show the highest mortality from tuberculosis. The investigation was divided into three phases: a statistical inquiry, a mechanical process inquiry, and the medical examinations. Dr. Edward R. Baldwin of Saranac Lake is chairman of the medical work, and the writer wishes at this time to acknowledge his unfailing encouragement and helpful guidance which has made this work possible, for there are many things to be done in an investigation of this kind before 1240 men are interested and vote to appear for the actual work. Through the trying preliminaries when the work hung in the balance Dr. Baldwin's assistance was invaluable. The writer owes a debt of gratitude to Dr. Kennon Dunham for blazing the trail, as his work saved much valuable time, labor and worry. Without Prof. William Snow Miller's work on anatomy of the lungs, which was at hand for reference and study, some of the observations recorded would have been impossible. The granite cutters have shown a remarkable spirit of cooperation. They did not appear because of any illness, but came up for examination in routine order by previous arrangement. Many of them had never had occasion to consult a physician before. They were all able to work and considered themselves in good health. As the work progressed serial films of these men were suggested and from the helpfulness received from the few cases studied serially it seems advisable to extend the serial idea to a greater number. Ten years will probably be consumed before conclusions can be drawn, so at this time a preliminary report is presented on the 386 men thus far examined. This number have all been taken stereoscopically, and it is planned to continue the examinations until 1,000 have been examined.

Nature of Report.—There are so many points worthy of detailed discussion that at this time only a survey of the general factors influencing the appearance of the films will be considered. As soon as possible separate studies of the apices, annular shadows, mediastinum, heart shadow, hilus, diaphragm, and Dunham's fans will be reported, but in the present paper only a general development of the lung lesion will be considered.

REVIEW OF LITERATURE

Roentgenological.—In this country at least

*Read by invitation at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., September 14-17, 1920.

very little seems to have been done in systematically investigating a dusty trade by means of the roentgen ray. The work at Barre[1] represents the first work of the Committee on Mortality from Tuberculosis in the Dusty Trades. The only other investigation is represented by the valuable contribution to be found in *United States Health Bulletin No. 85,* issued January, 1917, comprising *A Clinical Study of 433 Cases of Miners' Consumption among Zinc Miners in Southwestern Missouri,* by A. J. Lanza, with a chapter on Roentgen Ray Findings in 150 Cases, by Dr. Samuel B. Childs of Denver. In The American Journal of Roentgenology for June, 1917, Dr. W. W. Boardman reported three cases dealing with dust inhalation. After a thorough search of the literature he comments on the fact that it seems to be remarkably free from any discussion of this subject. He states that in the standard works on clinical medicine there was no reference to the roentgenographic appearance of the lungs in dust inhalation except in Barker's article in *Monographic Medicine* in which a brief reference was made. He states that the text books on roentgenography consulted were all silent except Robert Knox and Rieder. He was able to find only one journal article, and that by a German writer who reported five cases. In 1918, in the March number of The American Journal of Roentgenology, Pancoast, Miller and Landis reported 137 cases gathered from eight industries. Abroad one finds *The General Report of the Miners' Phthisis Prevention Committee of South Africa,* published under date of March 15, 1916. In this report of 189 pages only three and one half are devoted to a report of the 8,000 radiographic examinations made. It is not stated whether the exposures were made stereoscopically or not. The work of Collis[2] in England devotes very little space to the roentgenographic phase, being more in the nature of a statistical study.

Fig. 1 (130). Exposure eighteen years. Granite Pneumoconiosis stage B. Notice peribronchial thickening which is so common in granite cutters with complete absence of constitutional symptoms.

Fig. 2 (355). Exposure eighteen years. Granite Pneumoconiosis stage C.

Pathological.—The South African *Report* states that "it is important to understand the distribution of the lymphatic channels since it is by their means that dust particles which have been conveyed into the lung are distributed through the organ." Intermediate silicosis may be defined as a diffuse fibrosis due to the gradual accumulation of mineral

Fig. 3 (129). Granite fibroid pneumoconiosis stage A. Exposure twenty-five years.

particles in the lymphatic capillaries as a result of chronic obstruction of the lymphatic circulation. Dr. LeRoy Gardner of Saranac Lake Laboratory is in charge of the pathological work connected with the investigation and the following extract is from his paper read before The National Tuberculosis Association at its annual meeting in 1920:

"In guinea pigs after about three weeks' exposure small amounts of dust may be found enclosed in mononuclear intro-alveolar cells which often show mitotic figures. These cells are scattered everywhere in the alveoli from the pleura to the hilum. At about two months some of these intra-alveolar cells have begun to mobilize and have formed considerable collections of cells often so closely packed as to simulate giant cells. These cell masses lie in the alveoli along the course of the ductuli alveolares and about and within the small lymphoid collections occurring in the periphery of the lungs. As Miller has shown, such collections occur at the distal ends of the ductuli alveolares and at the division points of the vessels. Dust has already passed through the lung and lodged in small amounts in the tracheo-bronchial lymphatics. From three to seven months the same process continues with a steady increase in the amount of dust deposit. The invasion of the lymphoid tissue of the lung is more extensive and the larger nodules at the bifurcation of the bronchioles and bronchi become involved. All of the lymphoid tissue of the lung becomes very active and mitotic figures are very common even in the normally small peripheral collections. If the animal be set aside after dust exposure the lung makes rapid and effective effort to rid itself of the irritant. The clearing process has only been observed up to three months in animals dusted for seven months previously, but at that time practically all the dust is collected within large aggregations of round or oval mononuclear cells which lie in the immediate vicinity of much enlarged lymph nodules. Heavy deposits occur within such nodules and within the tracheo-bronchial lymph nodes.

Composition of Barre Granite:

Silicon Dioxide	69.56
Aluminum Oxide	15.38
Iron Oxide	2.65
Magnesia Oxide	Trace
Calcium Oxide	1.76
Sodium Oxide	5.38
Potassium Oxide	4.31
Manganese	Trace
Loss on ignition, CO_2 and moisture	1.02
	100.06

"According to Gardner[4] when examined under the microscope the unscreened dust may be roughly divided into large and small particles. The former, which could not possibly be concerned in an inhalation experiment,

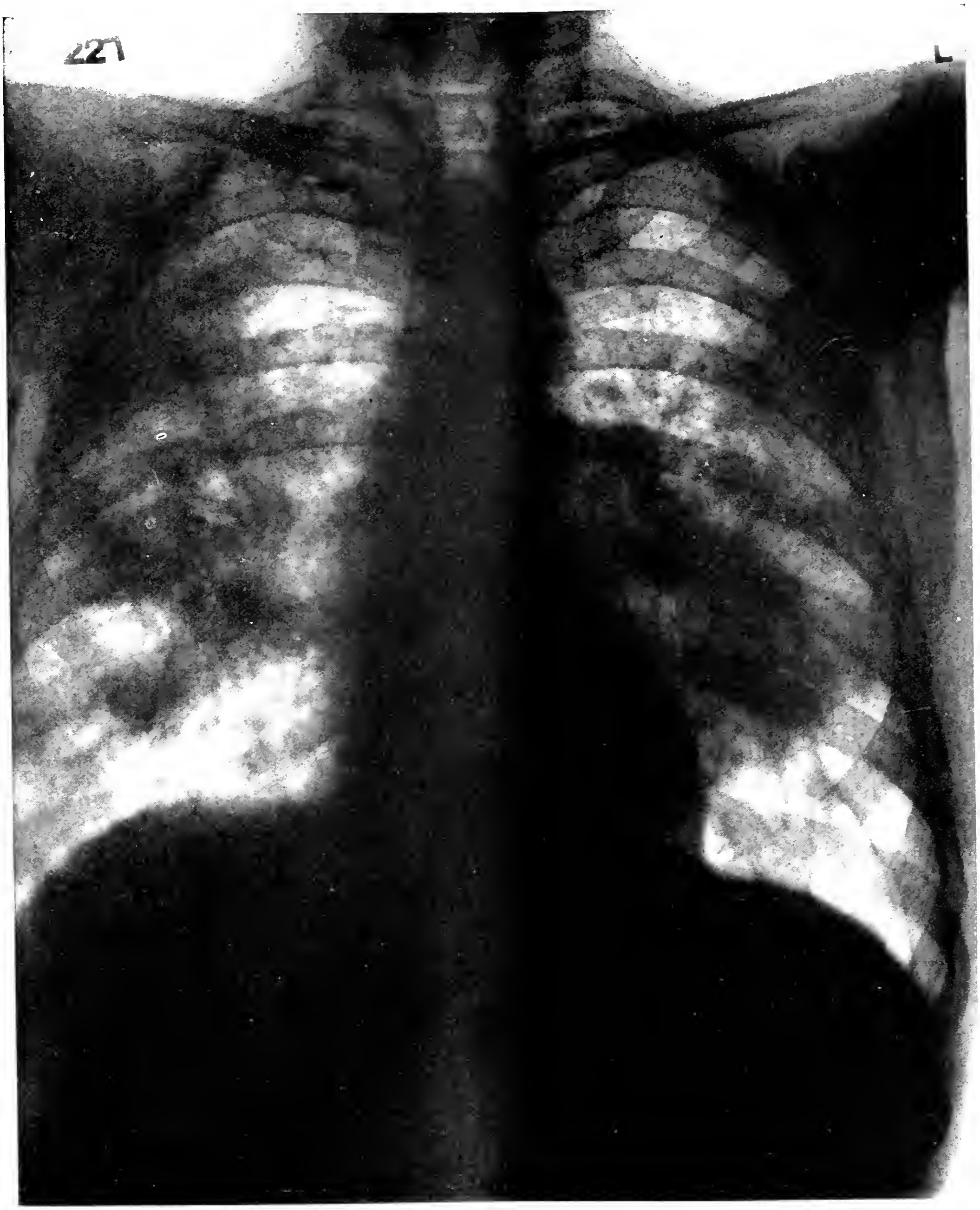


Fig. 4 (227). Exposure thirty-three years. Working every day. Granite fibroid pneumoconiosis stage C. Only symptoms slight cough, slight expectoration. Physical examination negative.

show an average size of 82 by 84 microns (ocular micrometer measurement). The smaller particles average 4.3 by 6.3 microns with a minimum of .028 by 1.4 microns by actual measurement. In shape the particles may vary greatly. Some are flattened polygonal masses with sharply cut edges and corners. Others are rod-shaped, often slightly curved, with sharply horizontal or square cut ends. Frequent vegetable cells and fibers are noted."

Samples of dust resulting from the use of the pneumatic tool have been examined by means of a small giant magnet made by the Victor X-Ray Corporation, and considerable steel has been extracted from a given quantity by means of the magnet, 2 drams of granite dust yielding 2 grains of steel. From this experiment it will be seen that we are dealing with two kinds of dust, that from the stone being worked and that from the tool used in working it, giving rise not only to a silicosis but to a siderosis as well.

PRESENT PROBLEM

In 1915, we find in Barre 2,050 granite cutters working, while in 1919 we find only 1240. The question suggesting itself whether this condition was peculiar to Barre alone, the total number of cutters for the United States was investigated and it was found that there was a corresponding diminution in the number of cutters throughout the whole country. For a number of years before the war immigration showed a decrease, and for the same number of years the number of entering apprentices was also very small. The statistician returned the report that an analysis of the death certificates for the past twenty years in Washington County indicated that 86 per cent of the cutters died from tuberculosis. The roentgen ray study was undertaken to assist in determining the incidence of tuberculosis among living cutters.

Technique.—It was annoying to develop the films of the cutters taken during the day only to find that there was such a variation in the quality. Exposures were made basing the changes in technique upon the difference in weight that the men presented, but this necessitated so much attention to the details of developing, offsetting over-exposure in some instances and under-exposure in others, that it was finally decided to make every factor constant except that of time, and a detailed set of measurements was instituted in order to discover if possible a measurement or measurements upon which exposure time might be based. Measurements were taken as follows: From the fifth dorsal vertebra by means of a pelvimeter to a corresponding point upon the sternum, from the left nipple to a corresponding point upon the scapula, from the sixth rib in the axilla to a corresponding point in the opposite axilla. These measurements were entered in the appropriate columns and with them the weight and height. The films were then developed in Eastman developer, using standard time and temperature, and the results noted. Two hundred and thirty-five sets were necessary before the table was worked out, and the day's work showed uniform quality regardless of weight or height. At first thought it was felt that the measurement through that part of the chest representing lung area would be the most satisfactory, but with the complete data at hand whenever the fifth-dorsal-to-sternum measurement coincided in the day's work the films showed the same quality, but when other measurements coincided the quality varied greatly. By means of a pelvimeter the chest expansion was watched in the areas representing the original measurements and it was found that the spine-to-sternum measurement changed very little, while the variation of the scapula-to-nipple measurement was influenced by the position of arms and inspiration. Consequently the fifth-dorsal-to-sternum measurement was adopted as the basis of estimating the patient's exposure time. These cutters were a splendid type physically, and while the table has been worked out on these muscular men it still holds good for the patients coming in the ordinary office practice. The technique is as follows:

Spark Gap—3½ inches.

Coolidge 30 M. A. Tube run at exactly 30 M. A., the hand being on the tube rheostat constantly during the exposure to make any adjustment needed at once.

Distance from tube target to film using upright stereoscopic shift 30 inches.

Developer time 5 minutes.

Temperature of Eastman developer 66° F.

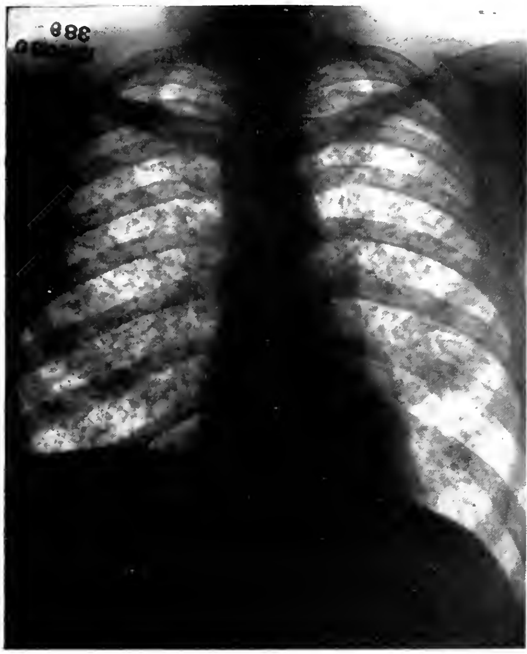


Fig. 5 (389). Fifty-two years of age, working every day. Exposure twenty-eight years. A professional swimmer, his last race being at age of thirty years, and the distance one mile. Sputum negative. Physical examination negative. No symptoms.

Fig. 6 (A.S.—11-5-20). Exposure fifty years. Repeated examination of sputum negative. Marked dullness all over base. Deficient breathing. Scattered bronchi.

Using the above constants the following measurements and time produced results:

FIFTH-DORSAL-TO-STERNUM

	Time by Time-Switch
6 inches	1½ seconds
6½ inches	2 seconds
7 inches	2½ seconds
7½ inches	3 seconds
8 inches	3½ seconds
8½ inches	4 seconds
9 inches	4½ seconds
9½ inches	5 seconds

In estimating the point upon the spine through which to pass the principal ray of the second exposure the lung is percussed down to absolute dullness on the back and the junction of the lower third with the middle third selected as the point for the passing of the principal ray of the second exposure. The tube stand is then elevated as usual for the first exposure. To avoid the clavicle in the apical region the suggestion of Dr. Bray of Raybrook Sanatorium has been adopted, namely, that of having the hips grasped between the thumb and forefinger of each hand and the shoulders thrown forward without elevation against the stereo shift. The patient is given a toy noise-maker such as is used when showing lantern slides, and is directed to signal as taught by Mr. Sampson of Trudeau Sanatorium when patient has taken a moderately deep breath and is ready to cooperate by holding it during the time necessary to secure both views of the stereo set. Patient signals when told that operator is all ready and is not allowed to breathe between the exposures of the stereoscopic set.

Classification of Films.—An effort was

made to prove that these men had tuberculosis, but not being able to do this it was found necessary to accept the diagnosis of pneumoconiosis, and a continued study of the films seems to bear out this diagnosis. A classification being more or less imperative in order that the films be studied systematically the following was decided upon:

Granite Pneumoconiosis Stage A
Granite Pneumoconiosis Stage B
Granite Pneumoconiosis Stage C
Granite Fibroid Pneumoconiosis Stage A
Granite Fibroid Pneumoconiosis Stage B
Granite Fibroid Pneumoconiosis Stage C
Granite Tuberculous Pneumoconiosis Stage A
Granite Tuberculous Pneumoconiosis Stage B
Granite Tuberculous Pneumoconiosis Stage C

It seems advisable to use the term Pneumoconiosis, as the two Greek words from which it is derived signify Lung Dust, which really represents the condition being studied, while the term Phthisis is apt to convey as many meanings as it has pronounciations. While the term Silicosis has been used it seems advisable in the interest of efficiency to use the term Pneumoconiosis and in connection with the qualifying adjective Granite, as the term Granite Pneumoconiosis suggests at once the nature of the lung lesion under consideration, the manufacturing process, percentage of silicon dioxide in the dust and the type of workman. The second classification, Granite Fibroid Pneumoconiosis, suggests not only the nature of the lung lesion and the industry in which it occurs but also the progress which the lesion has made. The third classification, Granite Tuberculous Pneumoconiosis, suggests the causative factor in producing the original lung lesion, the industry responsible for the lesion and the fact that tuberculosis has been superimposed upon pneumoconiosis. Taking up the various subdivisions under each main classification we first consider "Stage A" under the classification "Granite Pneumoconiosis." The films coming under this have a hilus density easily discernible and linear markings going to the first and second interspaces and increased perivascular markings in the bases. It is found that even outside of the industry the Barre residents examined as controls fall into this class as we have a dust hazard in the general atmosphere of the town. "Stage B" includes films that show linear markings radiating in all directions from the hilus to every part of the lung reaching almost to the periphery. "Stage C" in addition to the above shows a homogenous haziness over each lung between the linear markings. Under the classification "Granite Fibroid Pneumoconiosis Stage A" are included films showing a fibroid area not larger than 3 centimeters, "Stage B" films showing a fibroid area not larger than 6 centimeters, and "Stage C" films showing fibroid areas larger than 6 centimeters in their longest diameter. The classification "Granite Tuberculous Pneumoconiosis Stage A" represents minimal tuberculosis, "Stage B" moderately advanced and "Stage C" far advanced tuberculosis superimposed on granite pneumoconiosis.

Dust Exposure Periods of Men Examined.—The length of time that granite dust had been inhaled was represented by four months in one cutter and the maximum time by fifty years in another.

FACTORS INFLUENCING THE APPEARANCE OF THE FILMS

Mouth Breathing as a Factor.—It was most perplexing to find cutters with equal number of exposure years and working under the same conditions showing such marked differences in the appearance of the films. It became quite evident that given the number of exposure-years one could not even hazard a shrewd guess with any degree of success as to the probable appearance of the *x*-ray film. According to the experience of Watt, Irving Johnson and Steuart[5] the mouth-breather is more apt to develop silicosis than one who employs nasal respiration. Particular interest has been taken in keeping detailed data of the upper part of the respiratory tract, hoping to show the influence the nose and throat played in the de-

veloping of pneumoconiosis. All this data will be reported at another time, but it is sufficient to say that the defensive mechanism of the upper respiratory tract breaks down fairly early in granite dust inhalation. An adaptation of the upper resipratory tract to occupation takes place, an anesthesia of the tract developing as evidenced by the inability of a cutter to feel a pencil point when drawn across his pharynx. One may hold a throat mirror in viewing the larynx for an indefinite length of time, the cutter stating that he feels nothing in his throat. In view of these facts one wonders how efficient the cilia are, and with the sensory nerve endings of the trachea and bronchi anesthetized by adaptation to occupation there is absence of cough of irritation, thus encouraging the dust to remain in the lungs. Particular attention has been paid to noticing whether the men coughed while undergoing the examination work connected with the x-ray phase, and one could not fail to observe the almost entire absence of coughing among the men. The films belonging to the cutters showing mouth-breathing were separated from those showing nasal breathing, and a study was made comparing them with other films of the same exposure-period, with the result that one cannot help but observe that the films belonging to the mouth-breathers show a lesser lung lesion than nasal breathers. The explanation is that the usual curve of the inspired air is broken by mouth-breathing and the dust impinging upon the posterior pharyngeal wall is expectorated as soon as the accumulation warrants it, or is swallowed, with the result that very little of it reaches the trachea and the lungs are consequently spared.

Fig. 7 (185). Exposure thirty years. Ambidextrous. Even lesion both sides of chest.

Fig. 8 (58). Exposure twenty-seven years. Showing basal condition starting in left base. Notice calcification of ribs so common in cutters.

Nationality as a Factor.—It was noticed while looking over an accumulation of films representing several days' work that a fairly large number of them showed less density than the others. This seemed strange because the cutters appearing for examination during the three-day period represented were all men with an advanced exposure history. Laying the better films aside and referring

to the examination blanks it was discovered that the majority of these films were those belonging to Italians. It being felt that the constant viewing of films had blurred one's ability to appreciate different densities, the films were taken to a granite manufacturer with the request that he look them over and lay aside those showing less white in the lung field, paying no attention to shadows which represented the heart, ribs, etc. To my surprise his collection of films which he designated as better contained those of the Italians. Ten nationalities are represented in the examination work and the films were now studied from this angle with the result that they were found to line up somewhat as follows in order of excellence: Italians, Americans, English, Spaniards, Scotch, Swedes, Norwiegans, Danes, French and Irish. You will notice that there is a geographical distribution of these races, many of the better ones living in Southern Europe and many of those along the last of the list living in Northern Europe. They may be also classified on the basis of those living in dusty countries and those living in countries not so dusty. It cannot be denied that in the granite industry at least the Irish are punished severely, and it is a question whether they should be in a dusty trade—certainly not in the granite industry, as they represent a hazard under the present working conditions and should not be accepted as apprentices. In looking about for an explanation of the difference in susceptibility of the different nationalities one has a feeling that in the chests of the Italians the dust is filtered out so rapidly that it never is other than an irritant, while in the Irish for example it passes the irritant stage and becomes a foreign body.

Fig. 9 (177). Exposure fifteen years. Showing right basal condition just starting.

Fig. 10 (750). Right basal condition farther advanced. Exposure thirty years. Patient died two months later. Death occurred suddenly during night. Cardinal symptom was dyspnea.

Occupational Position as a Factor.—In studying the films two areas always showed an increase in density in linear markings in earlier stages, and as the lung lesion advanced this difference in density held good up to the point where the whole lung area on both sides was involved. These areas of increased density were represented by the portion of the lung field just below the left

clavicle and at the right base. In endeavoring to explain this increased density in these situations the occupational position of the men was studied and it was found that the pneumatic tool they use vibrates 3,200 times a minute, and in order to secure a basal support that the tool might be used to the best advantage the upper part of the right chest is compressed by the right arm and elbow and the lower part of the left chest is compressed by the left elbow and forearm. This apparently limits the respiratory action of the portions of the chest, and palpation of the same at work shows limited expansion in the compressed areas thus allowing more dust to find a resting place in that portion of the lung receiving most air. It has been stated by other observers that the progress of the lung lesion was greater on the right side below the clavicle, but the experience in Barre would lead one to suspect that the occupational position of the workers examined was different from that of the granite cutters. It would seem, then, that occupational position is a factor in determining the part of the lung in which a lung lesion from inhalation of granite dust has its inception.

EVIDENCE GAINED FROM NON-SERIAL FILMS

In a work of this kind one must of necessity study non-serial films, because it takes a cutter thirty years to produce a lung lesion which would be diagnosed if he had constitutional symptoms as lobar pneumonia. It takes him between twenty and twenty-five years to produce a lung lesion which would be diagnosed as broncho-pneumonia if he had constitutional symptoms. It is manifestly impossible to follow an individual cutter by means of serial films through thirty years of granite dust inhalation. For labor turnover, the migratory nature of the cutter and the ever recurring strikes necessitating his seeking employment in other industries for the time being at least, and from which he often fails to return if the occupational environment is congenial, are conditions incompatible with serial films extending over

Fig. 11 (319). Exposure thirty-two years. Showing progress of right basal condition. No symptoms.

Fig. 12 (270). Exposure thirty-five years. Taken September 8, 1919. Notice right basal condition.

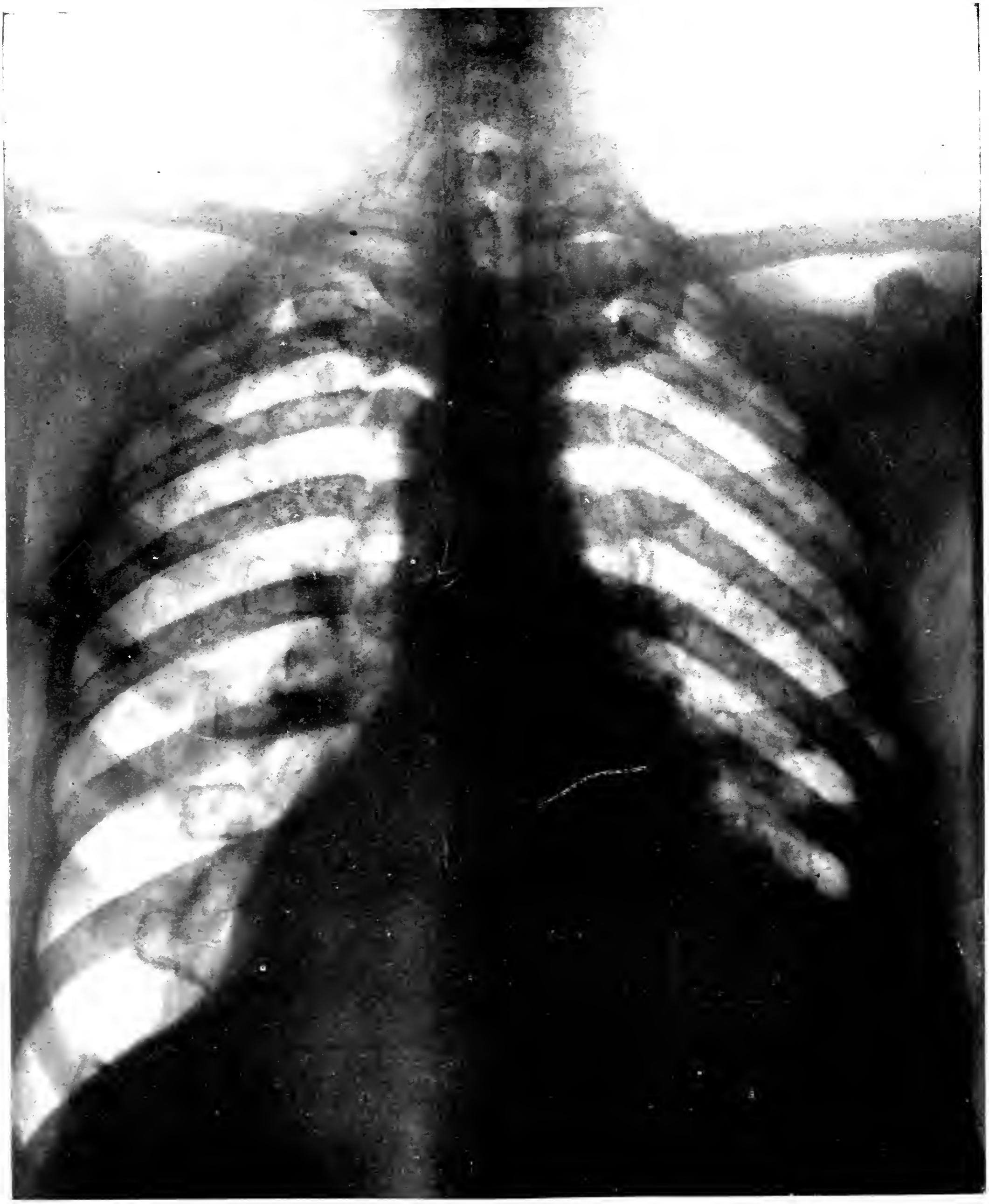


Fig. 13 (No. 160). Same patient as Fig. 12. Taken after two months' absence from granite industry. Note change in appearance of right base.

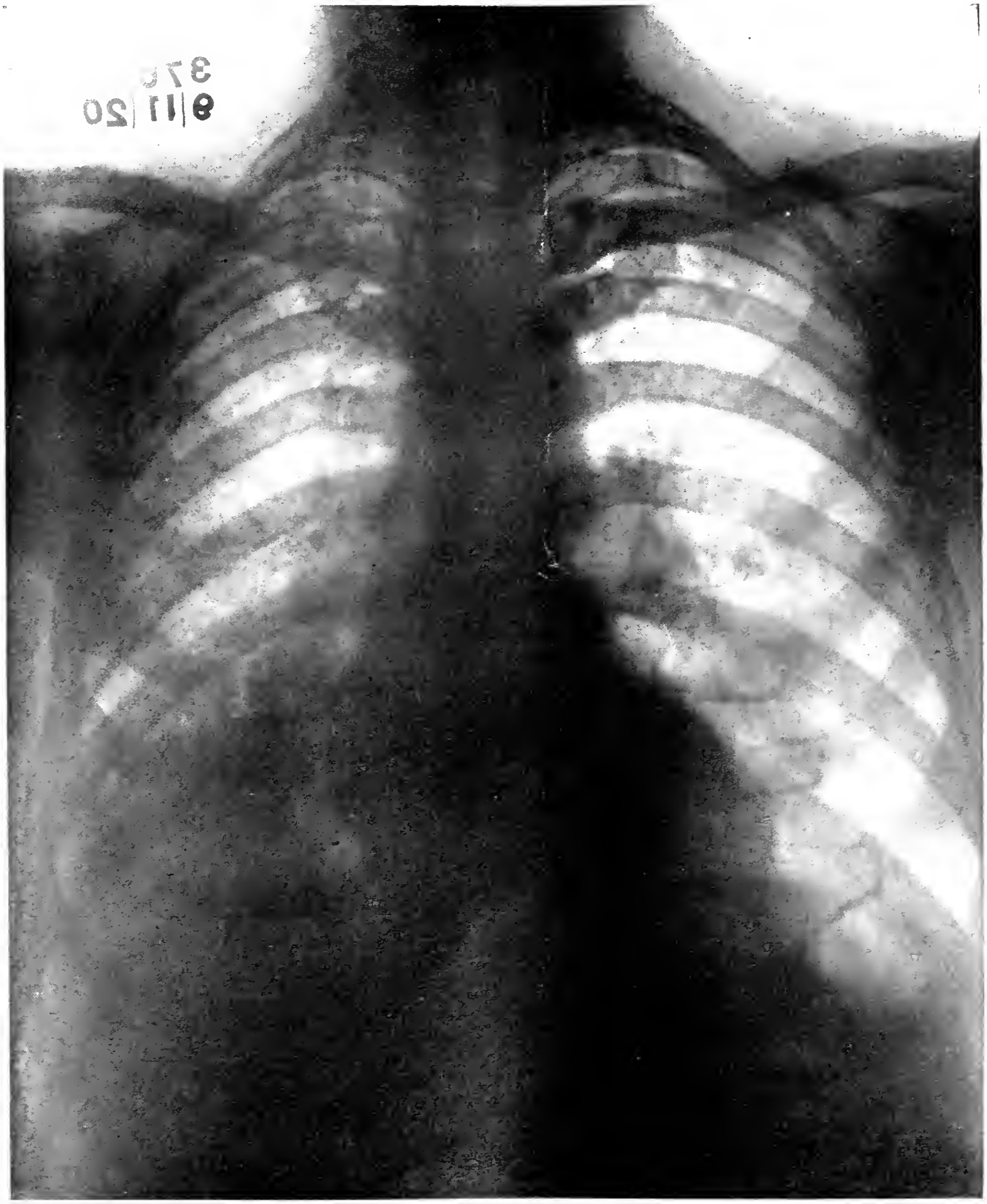


Fig. 14 (375). Same patient as Figs. 12 and 13. Taken five months after re-entering granite industry. Notice reappearance of right basal condition, on exposure again to dust.

any period of time. An effort is being made to select men who for various reasons will be expected to retain a permanent residence in Barre and take them serially, so that in the same individual the lung lesion may be traced from stage to stage. It is hoped to continue this until at least the pathological process observed in one cutter overlaps that seen in another. In the few instances where it has been possible to observe the lung lesion by means of serial films of the same cutter, the evidence has borne out the inferences made by studying several hundred non-serial films.

It is quite evident from this study why it is impossible to describe a normal or standard hilus. It would be as difficult as to describe a normal day or a normal reading of an outside thermometer. We learn to vary our sense of normal with the changing seasons of the year. In like manner we learn to vary our sense of normal so far as a hilus is concerned as the respiratory environment of the individual changes. A normal hilus for a granite worker is never seen because his intake of dust is changing from week to week, especially if he is experienced enough in the work to be an all-around man. If he is he uses varying processes of creating the finished product, depending upon the process he is detailed to for the time being. So one does not try after a while to describe a normal hilus, but rather looks upon the hilus as his lung indicator, telling what has gone on before and what is now going on. The hilus then represents the peripheral reception of the irritant, and in the case of the granite cutter it is a mechanical one with no ability to proliferate and no ability to produce toxic products for absorption with their production of constitutional symptoms.

The pathology seems to be the same whether the irritant is mechanical or bacterial, only in case it is bacterial the lung lesion is accelerated so that in a few days or a year at most results are produced that it takes years to produce with a mechanical irritant. In proportion to the amount of dust that is brought to the periphery of the lung by way of aspiration, in like proportion will the hilus show a change in increased area and density. On this point we feel sure, because we have seen in the same cutter the hilus diminish in size because the cutter was obliged to loaf owing to a severe eye injury, and on his return to the industry we have seen the hilus increase to the original size when inhalation of dust was resumed. With the hilus the lymph node nearest the hilus underwent a change, emptying during the loafing period and taking on its function and reappearing upon the film when work was resumed. These observations lead us to believe that the extension of the lesion is not from the hilus outward *per se*, but rather that the lesion is peripheral all the time, and the hilus change as to speed shows us how great the peripheral severity is.

As the hilus continues to act as an indicator of the dust brought to the tracheobronchial lymph nodes by the lymphatic system of the lungs, there comes a time when the first set of lymph nodes external to the hilus take on their function, being visible to the eye on the film as the cervical lymph nodes are palpable when they take on their function. As the study extends we are able to make out three sets of these nodes from hilus to periphery. For the sake of description these lymph nodes have been called "proximal set," "medial set" and "distal set." Now using one of these proximal lymph nodules, as we shall call them, for an apex of a triangular area, we shall find the base formed by two medial nodules of the same character. In turn using one of these medial nodules for an apex we shall again see the base of a triangular area formed by two lymph nodes, but this time they will be those of the distal set. The sides of these triangles are formed by linear densities.

From these triangular areas which at first contain the lung markings seen in the lung as a whole, we see Dunham's fans develop. If one is at all skeptical about the occurrence of Dunham's fans he will soon have that skepticism removed if he studies the films of

pneumoconiosis of a number of workers, for they are seen unilateral, bilateral and in almost any part of the lung. The right lung from apex to base seems to be able to accommodate five at one time with the bases to the pleura and the apices to the hilus in all except the lowest, which has its apex pointing toward the diaphragm. If one lays aside all of the films having a fan in the same area and then studies them the evolution of one of these fans will be watched until it occupies practically the entire upper left lobe with a stem extending back to the hilus as large around as a pencil. One has a feeling as the linear markings are studied that they are perivascular rather than peribronchial, because in cutters exposed for twenty years and then out of the industry for a period greater than five years, the bronchial twigs can be made out as an area of lesser density to the inner side of the linear markings. The inner boundary of the bronchial twig is seen as a thin white line, but there is no area of greater density accompanying it. These bronchial twigs can be followed quite a distance out into the lung structure. In regard to what is spoken of as peribronchial thickening we have seen it change during the ten weeks' strike in 1920, becoming lessened in width and irregular in border as the dust deposit was unevenly moved on to the hilus.

Fig. 15 (166). Exposure twenty-eight years. Bilateral Dunham's fans each involving first interspace trunk both sides.

Fig. 16 (91). Exposure twenty-six years. Stage 5 of one of Dunham's fans. Note the pleural detour.

Considering the lung lesion as it affects the proximal medial and distal sets of lymph nodules described, we first notice the proximal node appearing when the hilus has increased in width, reaching near this nodule. At first this nodule looks like the end of a cotton wound applicator and is adjacent to a bronchus on end. From its size of about six mm. in diameter it increases until it takes on the appearance of a tuft of absorbent cotton, its edges being blurred and irregular, the original density being perceived near the center as an area of slight increase in density over the surrounding area. About the time this is 2 centimeters in width the medial node appears and undergoes a change similar to that of the proximal node. In turn the distal node appears, and as it undergoes its increase

in area and density a haze will be noticed in the extreme periphery of the lung. This haze when viewed stereoscopically will be seen to occupy the plane of the pleura, while the lung density will be seen in its true plane. In the same individual, by means of serial films, this density was seen to appear in seven months. In another individual it was seen by the same method to disappear to a

Fig. 17 (96). Exposure twenty-six years. Working constantly. Dullness left apex. Patch of pleurisy below left nipple. Otherwise negative.

large extent during a two months' absence from his work. This area seems always to be triangular with its base towards the lung periphery and its apex towards the hilus. It has been felt that this density appearing in the pleural level is a detour of the lymph flow; the path between the periphery and the hilus being blocked, nature seeks to accomplish her end, namely, the removal of the irritant, by making a detour by means of the pleural lymphatics. This pleural haze has been seen extending from apex to various rib levels. An effort has been made to write down the evidence as gathered from a preliminary study of the films. Each one of you will probably correlate it with your own past experience and will probably draw your own conclusions.

SUMMARY

1. Film densities are influenced by mouth breathing, nationality and occupational position.

2. The machinery must be considered as a source of dust as well as the material being worked.

3. A standard exposure technique should be adopted as early as possible in a study of dust inhalation in order that one may feel sure of variations of density.

4. While classification of films is helpful, the lung lesion in a dust worker is like the shifting sand of the sea and each film should be judged by its own individual densities as portraying the pathology in the making in that particular individual.

5. Evidence tends to show that the lesion always remains peripheral and the lung reaction to an irritant is evidenced by densities appearing from the hilus outward.

6. It seems possible to parallel films of tuberculosis, pneumonia and various other pathological conditions of the lungs with the films of granite cutters, there being an absence of clinical activity in the latter, the mechanical irritant producing the same lesion as a bacterial one.

7. It would seem that many densities are being diagnosed as tuberculosis which should be considered as densities of pneumoconiosis.

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THE X-RAY SHADOWS OF LUNG SYPHILIS AND SYPHILITIC-TUBERCULOUS SYMBIOSIS IN THE LUNGS*

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WITHIN the past five years, thoracic syphilis has assumed a place of importance in clinical medicine, and our position as leaders in medical research makes it expedient that we give this subject more serious consideration. Attention has heretofore been concentrated upon lesions of the heart and aorta to the unjust exclusion of those which occur in the lung. Up to 1916, the references to pulmonary syphilis in the roentgen literature were remarkable for their scarcity, consisting of case reports from Dachtler,[1] Carman,[2] Pancoast,[3] Dunham,[4] and, possibly, others.

Pathologically, invasion of the lungs by syphilis was recognized by Virchow,[5] Depaul [6] and Pancritius,[7] and described in some detail by Fowler [8] and Stanley.[9] Clinically, many authors have directed their attention to it; some of these, like Osler [10] and McCrae, regard the condition as extremely rare and infrequently recognized, while others consider it to be relatively common. Dieulafoy [11] says "syphilis of the lungs is of the highest importance" and describes six forms, with very discouraging comments on diagnosis. The value of roentgenography for this purpose was brought to the attention of clinicians by the reports from the roentgenologists mentioned, and most writers since have emphasized the fact that the nature of the disease should make it amenable to *x*-ray differentiation. In spite of isolated reports, however, our specialty, as a whole, has taken the position that we can offer little assistance. If this were true, Carrera's [12] statement that the ultimate diagnosis of lung syphilis must wait on the necropsy and microscope would be the correct and hopeless outlook, for clinicians have already exhausted their physical and laboratory methods, and, if we cannot assist them, lung syphilis is likely to remain the *bête noire* of the internist.

However, this challenge presents too fine an opportunity for us to ignore. If we grant that lung syphilis is a clinical entity and comparatively frequent in occurrence; that the pathology in the lungs is characteristic in histologic change and in gross location; then the lesions should certainly be recognized on the radiograph.

This paper presents its material in two parts: I. Lung Syphilis; II. Syphilitic-Tuberculous Double Infection in the Lungs.

PART I. LUNG SYPHILIS

In 1916, we began a systematic search for lung syphilis by including this disease as a possibility in every lung examination, as there seemed to be no mechanical or biological reason for the frequently assumed freedom of the lungs from this infection. Inasmuch as roentgenographic interpretation consists purely of conclusions regarding tissue pathology, drawn from the shadows cast by disease changes, and since the antecedent pathological work on lung syphilis was "fragmentary and vague,"[13] the *x*-ray work necessarily was imperfect. However, several fundamental facts aided in forming a nebulous expectation of the shadows of lung syphilis.

1. The peculiarities in the anatomical structure of the lung, as demonstrated by Miller, with the relations between bronchi, arteries and lymphatics, have an intimate bearing on the interpretation of the shadows of all pulmonary lesions, including lung syphilis.

2. The characteristic method of invasion of active syphilis, wherever found, by ex-

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

tension along the arteries, is distinctly different from the extension of tuberculosis through the lymphatics. A consideration of the relations of lymphatics and arteries to the pulmonary subdivisions which are involved, indicated that there would be a distinct difference in the shadows of these two diseases.

3. Aside from the pathological differences, the clinical observation had been that the lesions of tuberculosis and syphilis occurred, as a rule, in different parts of the lung, the former in the upper and the latter in the lower lobes.

4. The characteristics of the shadow of tuberculosis being already definitely established, the differentiation would be between syphilis and other less common types of lung disease.

Basing our observations on these facts by selecting patients known to have syphilis and making a careful study of the pulmonary densities presented by them, certain types of shadow could, with a fair degree of probability, be classified as syphilitic. Then, by observing the resolution of such shadows after antiluetic treatment, the tentative observations could be confirmed as definitely as we could ever hope to confirm them during the life of the patient.

The handicap of a lack of accurate pathological knowledge was, to a large extent, removed by the publications of Warthin[13] on latent syphilis, in 1918, and the more recent observations of Carrera[12] on the specific lesions in the lung. It should be a matter of

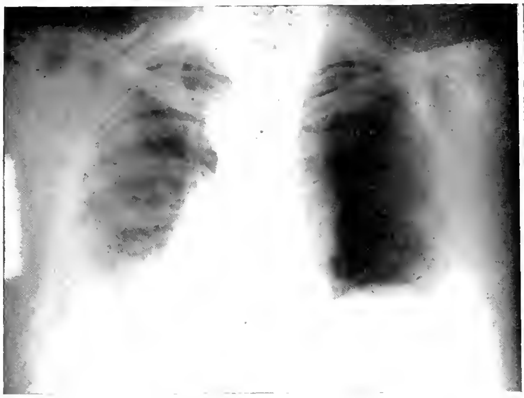

Fig. 1 (Patient 785). Peribronchial fibrotic type of lung syphilis. History of syphilis; Wassermann positive; sputum negative; abatement of lung signs under mercury.

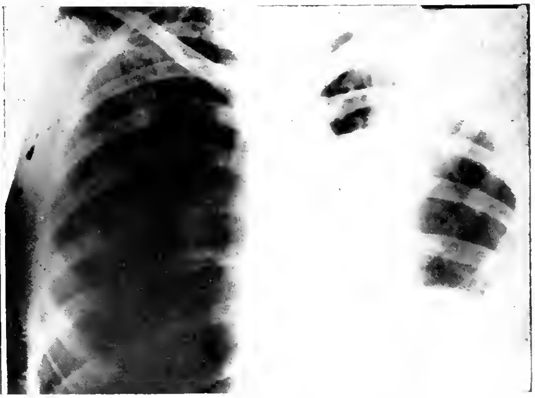

Fig. 2 (Patient 14552). Hereditary syphilitic. Early form of infiltrative type in the left base.

satisfaction to those pioneer roentgenologists who interested themselves in this supposedly rare condition, to observe that these belated pathological researches verified the accuracy of their radiographic forecast of tissue changes. The most important result of the pathological work was the furnishing of a basis for accurate classification of radiographic shadows and a definite explanation of some peculiar shadows which had been observed but not, heretofore, interpreted.

In terms of clinical pathology, we can distinguish three types of radiographic shadow produced by syphilitic invasion of the lung. The classification here differs slightly from that previously offered, in order to conform to recent discoveries.

1. The lesions of active or early syphilis produce shadows which are to be interpreted as (a) gummas, or (b) inflammatory consolidation or infiltration. Such shadows vary according to the virulence of the infection and the rapidity of the invasion.

2. The lesions of old, latent or hereditary syphilis produce shadows which represent (a) interstitial peribronchial or peri-arterial fibrosis, or (b) dense fibrosis of the lung or pleura.

3. In conjunction with thoracic syphilis, indefinite lung densities occur, the nature of which have not yet been determined, either by clinical observation, pathological research or radiographic characteristics. These densities correspond to those seen by Dachtler[1] in his cases reported in 1912.

The wide variation in the shadows of lung syphilis, from a simple peribronchial deposit of fibrous tissue in a limited lung area, to complete consolidation of an entire lung, is explained by Warthin's[13] distinction between the pathology of active syphilis and of latent syphilis.

When active syphilis invades the lung, there is extensive consolidation or inflammatory infiltration, usually in the lower lobe, due to the tendency of this infection to follow the larger arterial trunks. This localization, however, is not absolute, the first case in our records involving the upper left lobe. The shadows of this form of the disease may simulate those of primary carcinoma, or the partially resolved consolidations of pneumonia. The shadows are usually confluent, of varying density, inclined to irregularity and mossiness of the edges, and tend to mass along the heart border and large bronchial trunks. They may be confused with the shadows of bronchiectasis, abscess or pneumoconiosis.

When tissue resistance is sufficient to encapsulate the diseased area, gummatous lesions result. The shadows of gummas will vary in size; will usually be multiple; are not confluent; will have edges slightly irregular but more definite than consolidations; when caseous, they will have centers of diminished density; when healing, they become irregular in outline, show pointed projections of fibrous tissue which contract the lung and may obstruct bronchi. It is conceivable that gummas may be so thoroughly encapsulated that they will remain smooth in outline and heal without material effect on the surrounding lung tissue.

The interstitial or peribronchial fibrosis, with its end result of dense fibrosis of the lung and pleura, occurs in latent syphilis, where a slow inflammatory reaction, ending in fibrosis, is the typical pathology. This fibrosis may be peribronchial or peri-arterial,

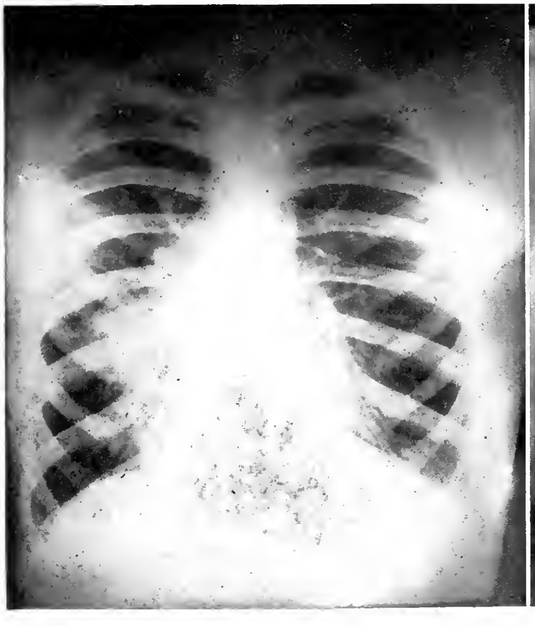

Fig. 3 (Patient 95). Syphilitic infiltration of the upper left lobe.

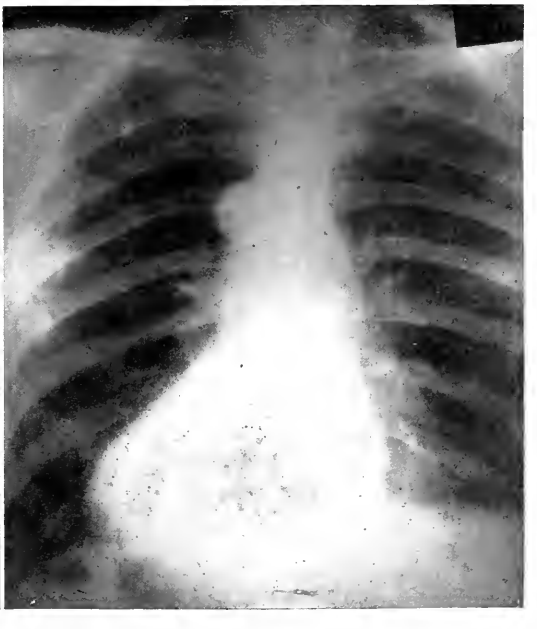

Fig. 4 (Same patient as Fig. 3). Shows change under antileutic treatment.

but resulting shadows will be the same, consisting of fine or coarse linear striations, springing usually from a dense hilus shadow and radiating to the periphery. The striations may occupy a limited area or involve both lungs generally. Other diseases and irritants, like poison gas, may produce a similar fibrosis.

Indefinite lung densities are frequently found in association with cardiac or aortic syphilis. Both Warthin and Carrera described lung changes which correspond to such densities, but were undecided whether they represented inflammatory reactions or passive congestion from mechanical conditions. While we wait on the pathological determination of this point, we wish to record our conviction that, radiographically, these densities are specific inflammatory reactions, and have been seen to disappear under antiluetic treatment. This has been observed both when they were found in connection with aortic disease and when they occurred in lungs without visible cardiac or aortic involvement. There are, of course, radiographic densities which are the result of passive congestion or pulmonary edema from cardiac embarrassment in syphilitic valve disease, but there should be no difficulty in differentiating these.

Since radiographic visualization of tissue change is only one of the many physical methods of investigating disease it would, manifestly, be improper and even impertinent to venture unqualified diagnoses of lung syphilis from radiographs alone. We need to take into consideration the personal history, the clinical evidences of systemic disease, the possible accompanying involvement of the heart or aorta, the other physical signs of lung disease, and the laboratory findings. However, the roentgenologist, as a consultant, has just as much right to consider all these evidences in connection with his special investigations, and produce the completed result as a diagnosis, as the clinician has to appropriate the radiographic interpretation and use it to connect his otherwise incomplete chain of evidence. In other words, we need to follow the teaching of a former distinguished President of this Society[14] and conduct ourselves as consulting diagnosticians.

Up to August 1, 1920, we have on record approximately 6500 examinations of the chest and heart. In this number we have made, or assisted clinicians in making, diagnoses of pulmonary syphilis in 172 patients; that is, of patients radiographed for suspected heart or lung disease, about 2.6 per cent had pulmonary shadows which we could reasonably conclude were due to uncomplicated syphilis. Many of these lesions were in combination with cardiac or aortic syphilis; in others there was no visible heart involvement. It will not be the function of this paper to enter further into statistical report or classification of these cases.

Part II. Symbiotic Infection

The characteristics of the tuberculous shadow are well known, and there is need to review them only so far as necessary to establish a basis of comparison with those of syphilis. Many illustrations, such as the goldenrod, the dandelion and the sunflower, have been suggested to fix the picture of the shadow of tuberculosis in our minds. The incongruity of illustrating disease pathology by means of a flower impels me to suggest a more appropriate simile. A thickly leaved tree, like our Western cottonwood, with a caterpillar web enmeshing numerous leaves and small twigs, sometimes large branches, graphically illustrates the tuberculous lesion; the shadow of this on a concrete pavement, with the sun at medium height, is an excellent representation of the radiographic reproduction. The leaves are the secondary lobules of Miller, the twigs and branches being the bronchi and accompanying vessels. Now, if we can fancy some destructive influence which blocks the circulatory system of these branches, so that the leaves wither and die, without web formation, we shall have an illustration of syphilis of the lungs, and the differences in their fundamental pathology.

As a general rule, tuberculosis, uncomplicated by mixed infection, will invade the upper lobes of the lung, and its shadows will be found over the peripheral distribution of some of the upper lobe bronchi. The bronchial twig or branch involved may be small and the shadow correspondingly limited, or the area involved may be large, even an entire lobe; but the shadow will be a peripheral shadow and will be in the upper lobe, whether the tuberculosis is of the minimal degree, barely perceptible on the radiograph, or whether it is of the most extensive degree, involving all branches of both upper lobes. When tuberculosis spreads from the upper lobes into the lower areas, or when it invades the central or basal regions primarily, we may expect to find an accompanying or antecedent mixed infection, producing an atypical localization of the tuberculous lesions. There may be exceptions to this rule, but it forms the clinical basis of our interpretation of tuberculous shadows, and many observations have only strengthened our conviction that this is a safe working basis, in spite of exceptions which we have observed and which others, no doubt, can cite.

The interrelation between tuberculosis and syphilis has been in the minds of clinicians since tuberculosis was isolated from other lung diseases and established as a clinical entity. The effects of the acquirement of tuberculosis by a syphilitic person, and vice versa, have been discussed at length by many writers, but without definite conclusions, due, no doubt, to the uncertainty regarding syphilitic infection in the lung. Until there was a clear conception of lung syphilis itself, naturally no very definite idea regarding its combination with tuberculosis could be formed. Certain clinical observations which have served only to befog an already very puzzling condition are all that we have to date regarding a sinister combination which affects from 15 to 20 per cent of our great army of tuberculous patients. We have the conflicting statements that syphilis acquired by a tuberculous person will exert a favorable effect on the course of the tuberculosis; and, conversely, that it will cause a rapid extension of the tuberculosis. We also

Fig. 5 (Patient 3134). Extensive syphilitic infiltration of right base. Almost entirely resolved following two injections of salvarsan.

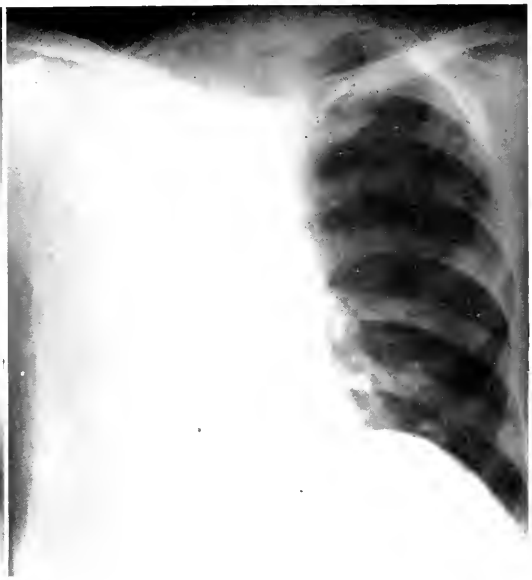

Fig. 6 (Patient 8675). Syphilitic sclerosis of lung and pleura. Wassermann positive. Autopsy showed complete destruction of lung tissue, with cicatrication, and large annular aneurysm of aortic arch.

have the confusing statements that a syphilitic who acquires tuberculosis will usually have an acute disease; and, conversely, that tuberculosis acquired by an old syphilitic behaves no differently from tuberculosis in a previously healthy person.

It is very apparent that here is a rich field for study. It is safe to assume that the previous observations on this double infection are not a safe guide, being necessarily based on an insufficient knowledge of the pathology of lung syphilis, and we can far better found our conclusions on our own investigations. Any such conclusions regarding a combination of syphilis and tuberculosis in the lung must give full consideration to the differences between an active, syphilitic inflammation, and the mild, slow fibrosis of old or latent syphilis.

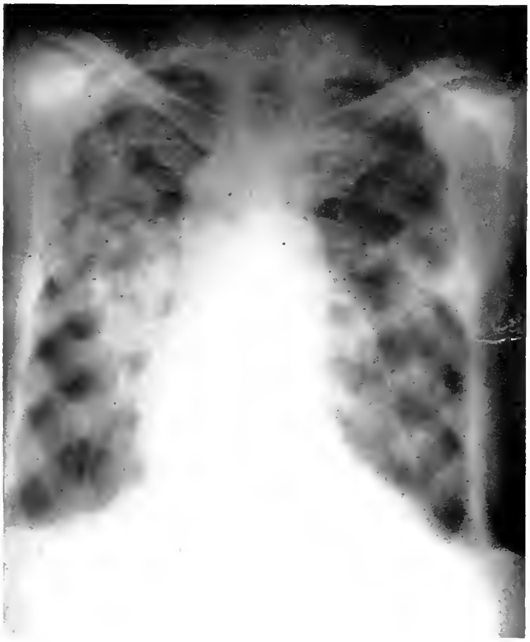

Fig. 7 (Patient 11495). Diffuse and irregular densities in lungs accompanying syphilis of heart and aorta, probably due to active lung disease.

Tuberculosis and syphilis may occur simultaneously in the same lung, each producing its own lesions, which frequently can be distinguished on the radiograph. Since each of these shadows have been described, it is not necessary to dwell further on them.

The two diseases may also occur as a true symbiosis. This peculiar condition was first brought to the writer's attention by the publication of the researches of Dr. Carl Spengler,[15] of Davos, in whose papers we found an adequate explanation for the brilliant therapeutic results of Wright in treating tuberculosis with injections of mercury salts. The term symbiosis carries with it a tacit denial of the supposed antagonism between the organisms of tuberculosis and syphilis, for which there is no biological or clinical evidence. Symbiosis occurs when syphilis prepares the soil, either by active inflammatory destruction of lung tissue, or by a slow, mild inflammatory congestion. The localization of tubercle bacilli, thus influenced by syphilis, is more widespread, and we find the lesions and shadows not only in the upper lobes, but also in the bases. A symbiosis is also represented by the effects of acquired syphilis on a latent tuberculosis. Here, as Dieulafoy expresses it, the syphilitic virus "hatches the tubercle bacilli and sows them broadcast." A widespread distribution of tuberculosis may be produced by the latent, as well as the active form of syphilis. However, active syphilis, when grafted upon a preceding tuberculosis, results in a very malignant disease, which may not be true when tuberculosis is implanted in a lung where latent syphilis already exists. It is conceivable that a well established fibrotic tendency produced by a long-standing latent syphilis of the lungs, will choke out a tuberculous process when the latter occurs as a secondary infection. This, however, is tissue resistance and not bacterial antagonism, a distinction which is of vital importance in treatment.

A very similar symbiosis is found when tuberculosis and streptococcic infection exist in the same lung. A generalization of the tuberculosis results, because tubercle bacilli develop with greatly enhanced rapidity and vigor on a soil where streptococci have already grown. This fact, first demonstrated in the laboratory, has not been given proper consideration in studying the effects of "influenza" on tuberculosis. When we deny that influenza has any effect on tuberculosis

we are making a categorical statement that tuberculosis is not affected by any of the virulent pyogenic organisms which infest the respiratory tract, since these are all concerned, either primarily or secondarily, in influenzal infections. Now we do know that streptococci affect tuberculosis very markedly, and it is entirely possible that the cases studied by Fishberg[16] were pneumococcic infections, while those studied by other observers, with contrary conclusions, were streptococcic infections. However that may be, the streptococcic-tuberculous mixed infection will produce shadows very atypical for tuberculosis, and which cannot be distinguished, radiographically, from the shadows of tuberculous-syphilitic mixed infection. When we find typical shadows of tuberculosis and other shadows, usually of more recent formation, in atypical locations and without the familiar characteristics of tuberculosis, we may conclude that some additional and more malign agent than tuberculosis is at work in that lung. We cannot here, any more than we can in pure lung syphilis, draw positive conclusions from the shadows alone. However, these frequently are quite suggestive, and if our radiographic examination gives the right clue and leads to the ultimate formulation of a correct diagnosis, it certainly has done all that can reasonably be expected.

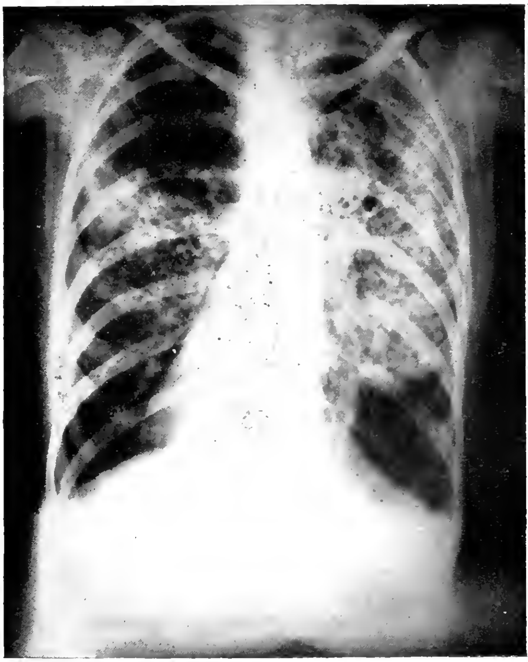

Fig. 8 (Patient 8133). Generalization of tuberculosis by streptococcic infection of the lungs.

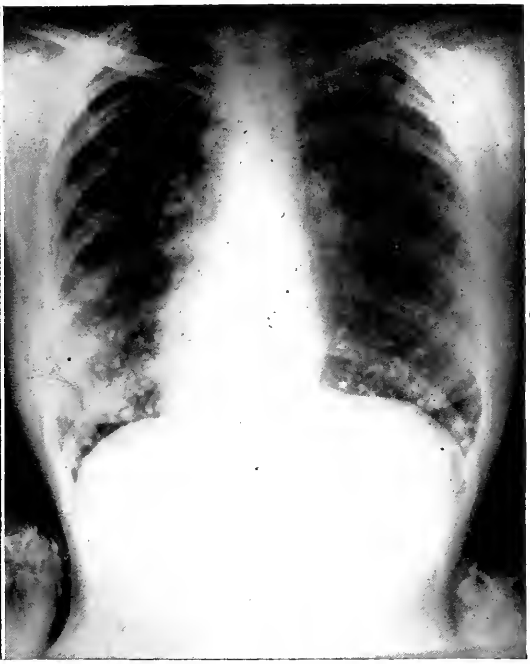

Fig. 9 (Patient 8825). Healed tuberculosis of the lungs and pleura. Stereoscopically lesions shown to be partly in the lungs and partly on the pleura. History of pneumonia, with slow recovery extending over two years.

When we find pulmonary tuberculosis, with cavities which fill up with streptococcus infected pus, and, beneath these, the shadows of a disseminated tuberculosis, the conclusion should be obvious.

When the tuberculous process is under the influence of a symbiotic syphilis, the characteristics of neither infection will be preserved. Dieulafoy cites a case of a caseous gumma whose outer rind was thickly studded with tuberculomas about the size of peas; the shadow of such a lesion naturally would be very atypical. We may find areas where the typical tuberculous shadows are preserved; elsewhere there will be groups of small, rounded, or irregular densities, repre-

senting small consolidations without detectable relation to bronchial stems. Where the syphilitic areas have been invaded by tuberculosis, or where the encapsulated tubercle is broken down and the bacilli disseminated by the effects of syphilis, we cannot expect to find any typical arrangement of shadow. The absence of infected cavities, the confluence of small consolidations along the heart border, large hilus masses, diffuse fibrosis, should suggest syphilitic rather than pyogenic double infection.

In the 6500 examinations previously mentioned, there were 948 patients who showed lesions of tuberculosis which had reached the advanced degree according to the classification of the National Tuberculosis Association. There were 192 cases whose radiographs had been disposed of and whose records were not clear enough to permit definite classification. In eleven patients there was acute tuberculosis, without radiographic evidence of a source of mixed infection to explain the generalization, and without history of antecedent acute respiratory disease. In 195 cases, the basal regions were practically free from abnormal shadow, the lesions being confined to the upper lobes, and these were considered to be essentially uncomplicated tuberculosis. In 550 patients the lesions had become disseminated into the lower lobes, and shadows were present which were atypical for tuberculosis and which could be explained only by some form of mixed infection. In 209, or over 22 per cent of the 948 patients with advanced tuberculosis, a diagnosis of combined syphilis and tuberculosis was made by us, or with our assistance. In the remaining 341 patients, a

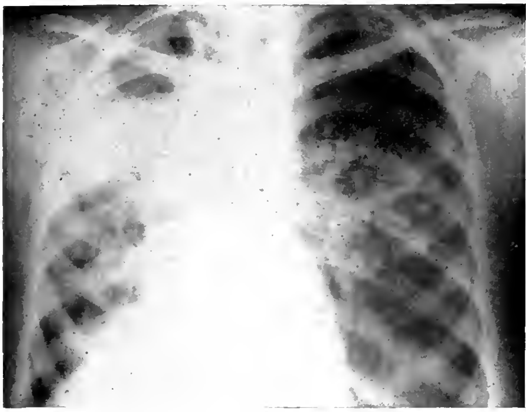

Fig. 10 (Patient 8325). Tuberculosis and syphilis, shadows in the left lung resembling carcinoma, but proven by course of disease and effect of treatment to be syphilitic.

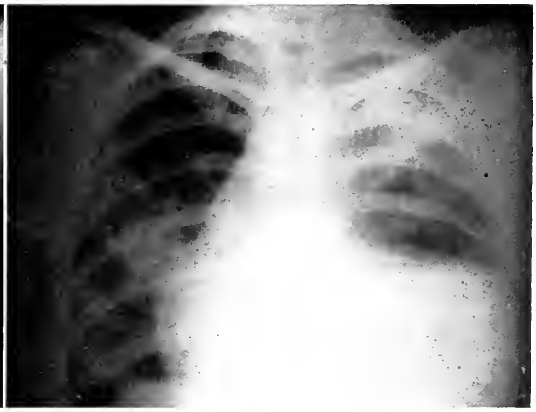

Fig. 11 (Patient 4668). Tuberculosis of upper right, with effusion in the base. Gummatous lesion of syphilis near left heart border. Entirely resolved under anti-luetic treatment, while the right sided lesions spread rapidly.

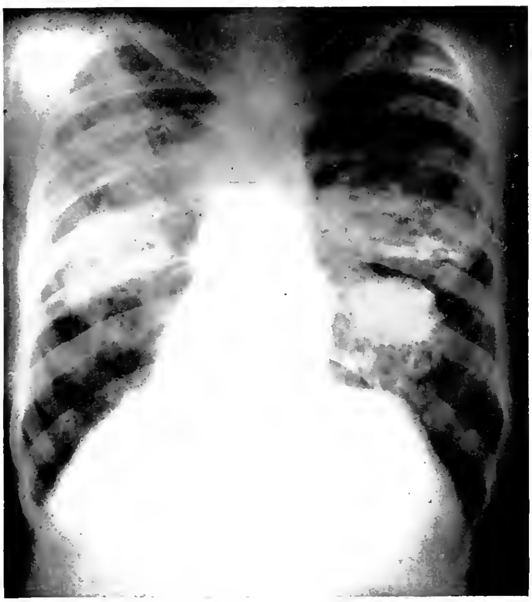

Fig. 12 (Patient 9553). Combined tuberculosis and syphilis of the lungs, with aneurysm of the aortic arch.

simple diagnosis of tuberculosis plus some form of undetermined mixed infection was the conclusion from the radiographic shadows. This report includes only patients showing extensive shadows, and we have, doubtless, failed to recognize the true conditions in many patients with less advanced disease.

In closing this inadequate presentation of a very timely subject, it is well to emphasize its importance from a therapeutic standpoint.

First: In the treatment of systemic lues, it is important to know whether the lungs are involved, since a Herxheimer reaction in the lungs may be serious.

Second: It is doubly important, in tuberculosis, to ascertain whether the patient combats this comparatively benign single infection, or whether a sinister combination with active syphilis must be treated.

Third: It may be triply important not to disturb the fibrotic changes of latent syphilis by arsenical treatment, if the tendency of this fibrosis is to arrest the tuberculosis.

In all events, roentgenological examinations are indispensable, and the opportunities for scientific research and for practical benefit to medicine and humanity afforded us in the symbiotic infection, are not exceeded by any other lung disease.

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DISCUSSION

Mr. H. W. Dachtler. This paper has been of considerable interest to me as the work I did some years ago was on the secondary manifestations of syphilis, and of course my findings were entirely different. We found at that time, that the roentgen examination was practically negative. In other words, these cases had physical signs of an early tuberculosis, including slight temperature, but no roentgen signs that would verify that, and our conclusions were that it was a diffuse bronchitis in the secondary stage of syphilis, and where we found such cases with negative roentgen findings, we suspected lues. I have had, during my experience, three cases that are somewhat similar to some of the cases shown by the doctor, where there were discrete nodules. All of these cases had a history of syphilis, but we were never able to verify them by postmortem examination.

I find it difficult to make clear that the findings we observed were not those of gumma. I have no cases in all my experience which I can identify as true syphilis of the lung. Those cases of secondary syphilis had antisyphilitic treatment, and they never developed any fibrosis, and for a very good reason—because the cases were early and they were cured, and the condition did not develop further.

Dr. Kennon Dunham. I know of nothing that is more important than the study of syphilis of the lung. We are getting, thanks to the *x*-ray man, more evidence every day which may some day help to substantiate a diagnosis of syphilis. I suppose there is not a large laboratory in the country that has not had definite lesions showing atypical densities which have cleared up under salvarsan. We have such plates in Cincinnati and we often treat them with salvarsan, but I hope, as roentgenologists, we shall not go on record as making a diagnosis of syphilis of the lung from these abnormal conditions. We can say that "such and such" a density suggests syphilis, but we cannot diagnose syphilis. The fact that a patient has a four-plus Wassermann does not mean that a given lung density is due to syphilis.

The specific organism of syphilis has not been demonstrated in the lung. Pathologists recognize two forms of pulmonary syphilis—

white pneumonia of the new born child, and gumma. Mr. Dachtler showed years ago that many cases which have physical signs of pulmonary tuberculosis but which have no roentgen findings of tuberculosis must be syphilitic, because they do not react to tuberculin and are cured by anti-syphilitic medication. Do not forget this important research of Mr. Dachtler. Even if we prove that certain abnormal densities within the lung are due to syphilis Dachtler has already proven that we may have pulmonary symptoms due to syphilis which do not give such abnormal changes.

Dr. Pritchard of Battle Creek, some time ago, showed me a series of slides in which lung densities had cleared up under salvarsan. I had similar plates in my own laboratory, and as I said before they are common in almost every large roentgen laboratory.

Let us remember that all these evidences of syphilis of the lung are not proof. Until the specific organism can be demonstrated in at least one such tumor we are not justified in doing more than suggesting pulmonary syphilis from our plates.

Dr. George W. Holmes. I have listened with a good deal of interest to Dr. Watkins' paper. We have had a few cases of lung syphilis which have been fairly well studied. The most interesting finding is a lesion in the bronchi causing a stenosis, and in some cases a complete collapse of the lung, producing complete dullness over the affected area The milder forms clear up under salvarsan when the bronchial stenosis is relieved. One advanced case came to autopsy. We could get no report from the pathologist except that "the patient may have had syphilis." We could not get him to say definitely that it was syphilis.

Dr. P. M. Hickey. I would like to ask the Doctor if he has any observations on syphilis of the pleura. I remember one case where I diagnosed tuberculosis with pleuritis, with a constant recurrent effusion, and the condition cleared up very quickly under salvarsan treatment.

Dr. W. W. Watkins (closing). I don't think I have anything particular to add, except to call attention to the fact that Mr. Dachtler stated in his cases there were no roentgen findings. In his original article, he mentioned in practically all of the cases that the bronchial markings were increased. This may or may not be similar to early syphilis changes.

I agree with Dr. Dunham thoroughly in the inadvisability of making the diagnoses from roentgenograms alone. My idea is to suggest syphilis as one of the things which produces the shadows which we see; never to make a positive diagnosis until the shadows have disappeared and the patient is well.

Answering Dr. Hickey's question, I have observed syphilis of the pleura in two cases, one where involvement of the pleura obscured the entire thorax on one side, where the probable diagnosis of syphilis was confirmed shortly after by autopsy. The other was a syphilitic pneumonia involving the pleura, in which the patient apparently recovered from the pneumonia, but the pleura always remained thickened.

ANEURYSM OF THE AORTA AND ABSCESS OF THE TRACHEOBRONCHIAL LYMPH GLANDS

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CASE 280177, Mrs. W. S., aged twenty-nine, wife of a farmer, was admitted to the Clinic July 15, 1919. Her health had been good until three months before admission. With the exception of abscessed teeth, several of which had been extracted about six weeks before, she had been in good health. The onset of her illness was gradual with a general tired feeling and some pain in the right side of the chest and around the heart. Her symptoms were attributed to overwork, but rest and later one week in a hospital failed to improve her condition. Within two weeks of the extraction of her teeth her temperature rose in the evening, reaching an average of 99 degrees; her pulse was rapid, and her breath short on exertion or when she was lying on her back. She choked at times when taking food. Half an hour after eating she had coughing spells in which she raised large amounts of clear sputum. Later a wheezing in the throat of gradually increasing severity was noted. She lost seven or eight pounds in weight during her illness.

Examination revealed slight bubbling râles over the chest. The heart was not enlarged; a systolic murmur was heard only at intervals; the pulse was rapid and irregular. The abdomen and pelvis were negative. The systolic blood pressure was 120, the diastolic was 80, the pulse was 100, and the temperature 99.5°. Examination of the blood was not recorded. The Wassermann reaction was negative.

Roentgen examination revealed a mass bulging into the upper mediastinum which with the fluoroscope proved to be non-expansile but was thought to be an aneurysm of the arch of the aorta.

The patient died four days after admission to the Clinic; the necropsy findings were as follows:

A large spherical, encapsulated, non-tuberculous abscess of the tracheobronchial lymph nodes (from 10 cm. to 12 cm. in diameter) was found. This mass, situated at the bifurcation of the bronchi, rested behind the bronchi, more to the left side, in front of the esophagus, and against the right pulmonary artery and vein and the descending arch of the aorta. There was evidence of extensive compression of the trachea and of the esophagus. The bronchial tree was filled with unexpectorated mucus and the entire venous circuit was markedly engorged. The body was strikingly livid and showed moderate emaciation with some edema.

CASE 8734. Mr. G. R., aged fifty, a bartender for a time and later a stationary engineer, was admitted to the Clinic August 28, 1919, complaining of a dull pain in the left chest. This pain was not influenced by respiration, but was accentuated by coughing or sneezing. He had had left side pleurisy with effusion five years before and five attacks of pleurisy in the intervening period. He had left side pneumonia in 1918 and in 1919 was confined to bed for several days with "chest trouble." At this time he had a tickling sensation extending down the left bronchus, followed by a slight cough and a small amount of whitish expectoration. In 1908 the patient had been treated at the Clinic for urethral stricture; he had had chancre at the age of twenty-seven and a history of gonorrheal infection over ten years. He complained of shortness of breath, weakness, aching between the shoulders at night, occasional night sweats, and that he was incapacitated for work. He had lost twenty pounds in weight in six months.

Examination revealed general adenopathy, expansion was limited on the left side of the chest; the percussion note was flat; vocal resonance and vocal fremitus were diminished. The breath sounds on the left side were distant; there were no râles, and no changeable dullness. The pulse was regular; a systolic murmur heard at the base and to the left of the mid-sternal line was believed to be an accentuated second sound. The systolic blood pressure was 136, the diastolic 92; the hemoglobin and blood count were normal. Examination of the sputum, the Wassermann reaction, and the electrocardiographic findings were negative.

Roentgen examination revealed a dense shadow throughout the entire area of the left lung. This suggested fluid, but aspiration failed to reveal it. An attempt to elicit fluid two days later by the same method failed and a small incision was made, deep enough to allow a few tiny bubbles of air to escape. The pleura was not appreciably thickened but appeared to be adherent to the lung. Pneumothorax did not follow these operative procedures.

The patient returned to his home September 2, and word was received of his death in November.

We are indebted for the following notes to Dr. T. R. Martin, of the Duluth Clinic, who performed the necropsy:

"On opening the chest both pleural cavities were found to be obliterated by old adhesions and the pericardium was adherent to the pleura on the left side. The lungs and heart were removed *en masse;* in stripping down the descending aorta the knife met with an obstruction, which proved to be an aneurysm of the first portion of the descending aorta, about 9 cm. by 10 cm., containing an organized clot. The posterior wall of the aneurysm was firmly adherent to the spine and had produced pressure necrosis on the lateral aspect of three of the dorsal vertebrae.

"There were no abnormalities of the heart or pericardium except calcareous deposits

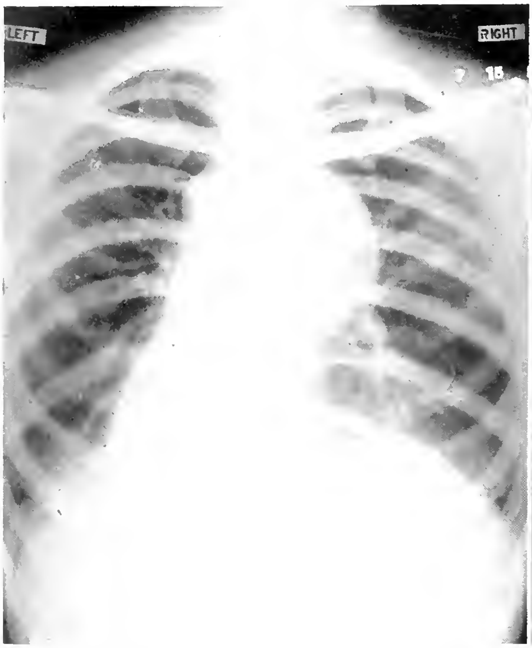

Fig. 1. Case 280,177. Shows shadow bulging into upper mediastinum.

Fig 2. Case 8734. Shows dense shadow in area of left lung.

at the bases of the cusps. The aorta showed numerous calcareous plaques at the site of the aneurysm. On introducing the finger through the auricle into the pulmonary vein an obstruction was met which suggested an acute angulation of the vein from pressure and distortion by the adherent aneurysm. The pulmonary artery on the left side was patent.

"The left lung was dark red, glistening, and moist; on section it was firm and liver-like in consistency and contained no air.

"There was nowhere any evidence of tumor formation.

"A roentgenogram was made of the heart and left lung removed from the body and in this the left lung cast a shadow more dense than the heart free from blood suggesting that the antemortem shadow in the left lung was due to passive congestion."

In Case 280177 the plates and fluoroscopic examination revealed a non-pulsating shadow bulging into the upper mediastinum, which could not be distinguished from the arch of the aorta (Fig. 1). In spite of the patient's age, a negative Wassermann reaction, and the fact that the shadow was non-expansile, aneurysm, in our opinion, was the logical diagnosis. In the literature it is generally agreed that aneurysm rarely occurs without a coexistent history of syphilis; on the other hand, it is known that patients may acquire syphilis unknowingly and that the Wassermann reaction may be negative in the presence of syphilitic infection. No expansile pulsation was observed in the shadow in this case, but it is not always present in aneurysm of the arch of the aorta.

In Case 8734 the roentgen findings were definitely those of fluid in the pleural cavity (Fig. 2). The course of the aorta could not be defined because of the extent and density of the shadow. The clinical findings were as characteristic of fluid as were the roentgen findings and the history of repeated attacks of pleurisy and a left side pneumonia was definitely misleading.

In corresponding with Dr. E. L. Tuohy of the Duluth Clinic we learned that because of the patient's history of syphilis he had earlier in the summer been given rather intensive treatment for syphilis without any apparent improvement in his condition.

A noteworthy feature of these two cases was that the Wassermann reaction was negative in both, although in the second there was a definite history of syphilitic infection.

These two cases are of interest because the roentgen findings were considered characteristic enough to allow of a definite diagnosis, yet necropsies proved them to be incorrect.

PELVIMETRY BY MEANS OF THE ROENTGEN RAY*

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AND
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By the use of films and double screens, it has recently become possible to get clear pictures of the maternal pelvis and the fetal skeleton at full term. This seemed to us to reopen the question of roentgenographic pelvimetry.

Martius[1] has given a very complete review of the literature on the subject up to 1914. After the first simple comparisons of roentgenograms of the patient with those of dried abnormal pelves, various mechanical and mathematical methods were developed to correct for parallax and foreshortening. The mechanical method culminated in the very complicated and expensive chair designed by Kehrer and Dessauer[2], which reconstructed by threads in space the straight lines connecting target, object and plate image and measured between their intersections. Martius found their method accurate enough, but they themselves were unable to get plates clear enough to measure after the first few months of pregnancy. The mathematical method culminated with that of Runge and Gruenhagen[3] in 1915, which is both simple and accurate. The only special apparatus used is a plate tunnel and a plumb-bob. They availed themselves of the stereoscope to identify the points from which to measure on the plate, a refinement first used by Manges[4] in 1912. It is a simplification of this method that we are offering.

In using films, it seemed desirable not to use the edges to orient them by, as Runge and Gruenhagen had done with plates, so we have had a plumb-bob impress its shadow on each exposure. We have discovered a simple construction for the horizontal projection of the desired diameter, which is even easier than the perpendicular from which Runge and Gruenhagen measured, and in addition simplifies the final calculation.

THE APPARATUS

We are using a tube-stand and table of standard make, the double screen cassettes being carried on the plate changer provided in the table. Across the celluloid window, somewhat above the middle, is stretched a wire (about 20 gauge). In the center of the 1 mm. aluminum filter is a very small lead ring, from which hangs on a cotton string a plumb-bob, consisting of a rod 3 by 50 mm., with two rods 1 by 30 mm. set through it near the end at right angles to its long axis and to each other.

METHOD OF TAKING THE PICTURES

The target is set 88 cm. above the plane of the film. We have chosen this target distance arbitrarily. The shadow of the plumb-bob is observed on a bare screen, and the tube holder is tilted until the shadows of plumb-bob and lead ring are concentric, thus bringing the plumb-bob vertically below the target. The patient is made to lie down on the table, with her pelvis over the celluloid window, a lead marker is placed under her right hip, the tube is brought over the right iliac region and an exposure made. The tube is shifted 10 cm. to the left parallel to the wire above mentioned, and another film exposed. It is necessary that the exposures be full, for an under exposure will fail to show the shadow of the plumb-bob, and the promontory of the sacrum will probably be obscured by the density of the fetal head. With a radiator

*Read at the Winter Meeting of the Pacific Coast Roentgen Ray Society, and the Western Section of The American Roentgen Ray Society, San Francisco, California, December 10, 1920.

Coolidge tube about 15 sec. at 30 ma. at a 4 inch gap has given readable pictures.

MEASURING THE FILMS

The films when dry are placed in the stereoscope, or are viewed on the light box with a prism hand stereoscope, and the points marked between which measurement is desired, e. g., the promontory and symphysis, the ischial spines, the brim at sacro-iliac joint and ileopectineal eminence, etc. Then on the light box a piece of clear celluloid is laid over one of the films, and on it marked (1) two dashes over the shadow of the wire, (2) the center of the plumb-bob, and (3) the points on the pelvis, labeling each pair. The celluloid is then laid over the other film, setting the dashes over the shadow of the wire, and the mark for the plumb-bob exactly 10 cm. from the second plumb-bob shadow. The points on the pelvis are then marked in their new positions. Draw lines connecting the plumb-bob dots with the pelvis dots belonging to each, and another connecting the intersections. The tracing for measuring, say, the conjugata vera, will then appear thus (see Fig. 1).

A centimeter scale laid on y gives the length in centimeters of the horizontal projection of the required diameter. A special scale laid on a and b gives the height in centimeters of each end of the conjugate above the plane of the film. The length of the conjugate is then computed from the formula:

$$x = \sqrt{y^2 + (a-b)^2}$$

ACCURACY

As a check on the method we have used a light wire 10 cm. long with spherical knobs on the ends. This is laid across the symphysis when the exposures are made. If calculation from the films gives the length of this correctly, then one may be sure that no mistakes were made, and can trust the calculations for the other measurements. Accuracy in determination of the pelvic diameters will depend almost entirely on the accuracy with which the points are marked on the films. That this is a real cause of error was shown by determinations on dried pelves, where the results at times differed from the calipered lengths of the antero-posterior diameters by as much as 4 mm. This I believe was due to the difficulty of marking accurately the posterior

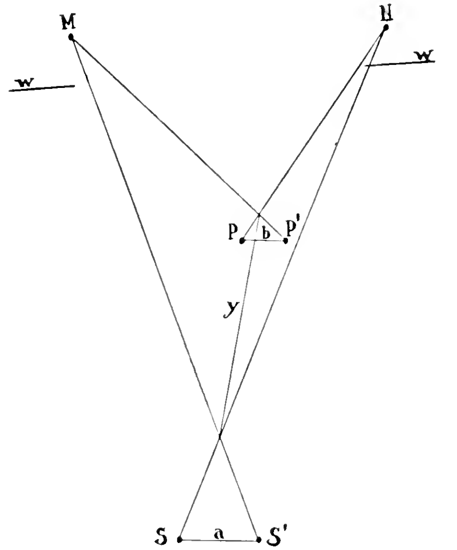

Fig. 1. Tracing ready for measurement. M and N are the plumb-bob marks. w and w mark the wire, P and P′ the promontory, and S and S′ the symphysis.

surface of the symphysis. The promontory of the sacrum is also, to a less degree, a source of uncertainty. The oblique diameters of the inlet and that between the ischial spines are, however, always very definite, and these are not only of prime importance in the mechanism of labor but are most unsatisfactorily estimated by the classical methods of pelvimetry. Error here has been less than 2 mm.

It should be pointed out that the method we have described is more widely useful than merely for pelvimetry. It can be used for measuring almost any of the dimensions of the skeleton, and perhaps even of soft parts. By taking a third exposure to rule out movement, the dimensions of the fetus may be estimated.

We wish to thank Dr. A. B. Spalding for the interest he has taken in this problem and for the use of clinical material from the obstetrical service of Lane Hospital.

For completeness the mathematical treatment of the problem is given below, but an understanding of it is not necessary in the actual use of the method.

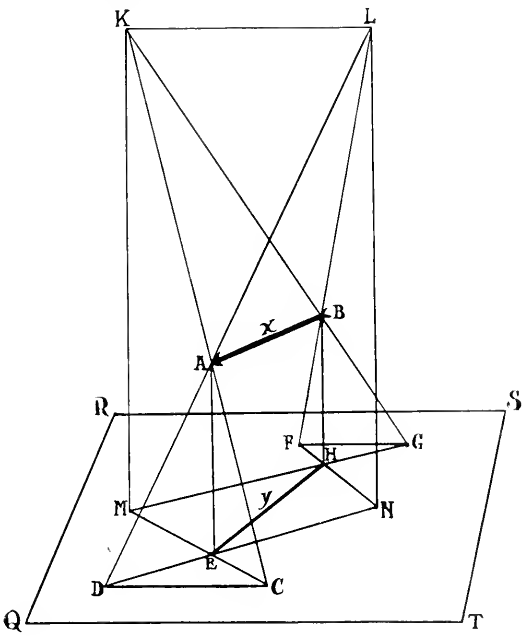

Figure 2.

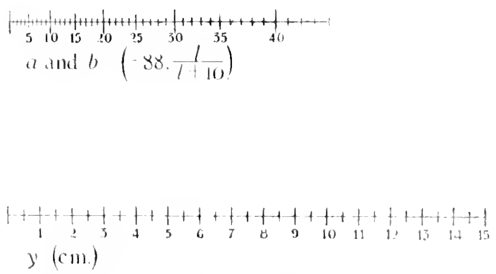

Fig. 3. Special Scale for Measuring the Tracing.

The unknown points A and B are projected onto the horizontal plane QRST from the two positions of the target at K and L, showing as the points D, C, F and G. M and N are the plumb-bob shadows and lie vertically below K and L respectively. (Fig. 2.)

Since in the triangles KMC and LND, KM and LN are vertical, MC lies vertically under KC, and ND under LD. Therefore E, the intersection of MC and ND, is vertically under A, the intersection of KC and LD; i.e., AE is vertical.

Similarly BH is vertical.

Since HE is horizontal, the figure ABHE is a right trapezoid. Its hypothenuse, AB, is the length to be measured.

$$\therefore (AB)^2 = (EH)^2 + (AE - BH)^2$$

EH is y in Figure 1 and directly measurable; and AB is the unknown length x.

$$\therefore x^2 = y^2 + (AE - BH)^2$$

$$x = \sqrt{y^2 + (AE - BH)^2}$$

Since KL is parallel to QRST, KL, DC and FG are all parallel.

$$\therefore \frac{KL}{DC} = \frac{KA}{AC}$$

$$\frac{KL + DC}{DC} = \frac{KA + AC}{AC} = \frac{KC}{AC}$$

$$\text{But } \frac{KC}{AC} = \frac{KM}{AE}$$

$$\therefore \frac{KM}{AE} = \frac{KL + DC}{DC}$$

$$AE = KM. \frac{DC}{KL + DC}$$

$$\text{Similarly } BH = LN. \frac{FG}{KL + FG}$$

We have chosen KM and LN = 88 cm. and KL = 10 cm.

$$\therefore AE = 88. \frac{DC}{DC + 10}$$

$$\text{and } BH = 88. \frac{FG}{FG + 10}$$

If, now, we construct a scale on which a length of 1 cm. reads $88. \frac{1}{1 + 10}$, we can by applying it to DC and FG, read off directly the magnitudes of AE and BH respectively. Let us call these readings a and b, then the formula becomes:

$$x = \sqrt{y^2 + (a - b)^2}$$

For convenience we have printed on a piece of celluloid a centimeter scale for reading y as well as the special scale for reading a and b. (See Fig. 3.)

SUMMARY

A simple method is described for measuring bony dimensions, notably of the female pelvis, by means of roentgen rays. The special apparatus required comprises: 1. a cross-arm plumb-bob. 2. An aluminum filter with small lead ring from which to hang the bob. 3. A light bar of known length for an automatic check on the accuracy of the exposure-making. 4. A special scale to lessen the burden of the calculations. (See Fig. 5.)

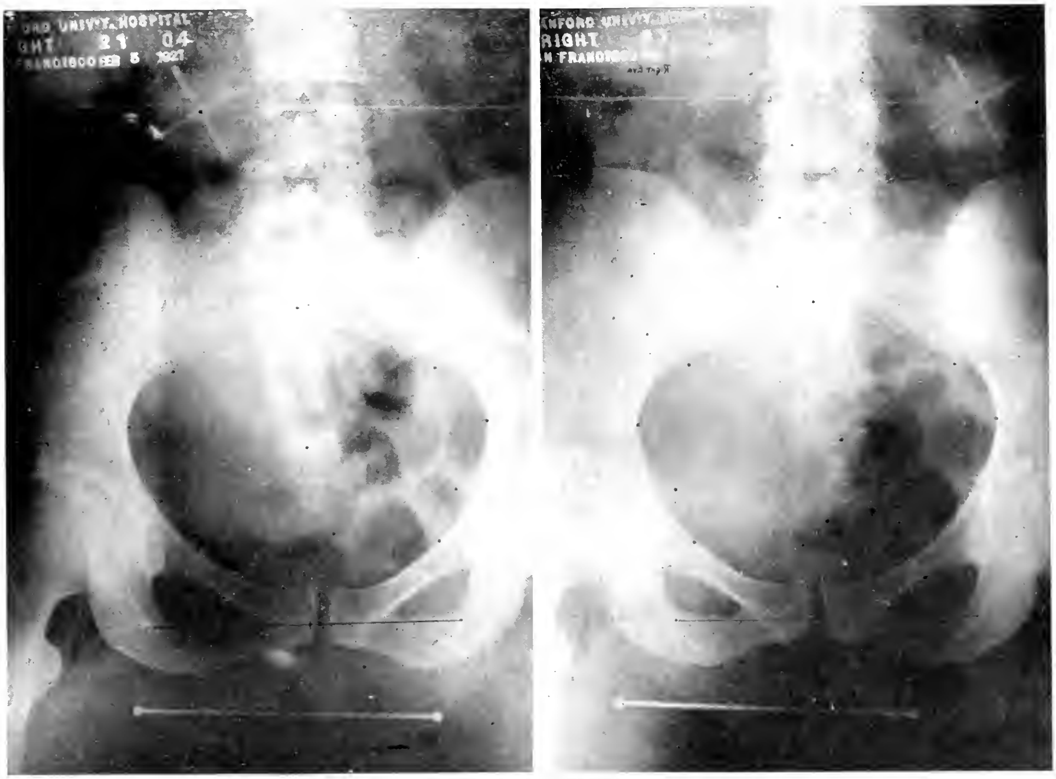

FIG. 4. The two films marked and ready for tracing. Dots have been put at the ends of all the principal pelvic diameters (internal). The line drawn between the ischial tuberosities is for the measurement of the anterior and posterior sagittal diameters. (The films taken at term show hardly enough contrast for satisfactory reproduction.)

The following are the measurements of this pelvis.

Pelvic inlet:	Anteroposterior	$\sqrt{9.5^2 + 6^2}$	= 11.2 cm.
	Transverse	$\sqrt{13.3^2 + 1.5^2}$	= 13.4 cm.
	Right oblique	$\sqrt{10.9^2 + 5^2}$	= 12.0 cm.
	Left oblique	$\sqrt{10.8^2 + 7^2}$	= 12.8 cm.
Plane of least dimensions:	Anteroposterior	$\sqrt{4.7^2 + 9^2}$	= 10.1 cm.
	Transverse	$\sqrt{11.2^2 + 1.5^2}$	= 11.3 cm.
Pelvic outlet:	Anteroposterior	$\sqrt{2.1^2 + 6.5^2}$	= 6.8 cm.
	Bisischial	$\sqrt{11.7^2 + 0}$	= 11.7 cm.
	Anterior sagittal	$\sqrt{1.1^2 + 4^2}$	= 4.1 cm.
	Posterior sagittal	$\sqrt{5.8^2 + 6^2}$	= 8.3 cm.

(Caesarian section was done for threatened eclampsia and at operation the true conjugate was measured and found to be 11 cm., a discrepancy of 2 mm.)

[NOTE: Since sending this in for publication we have acquired a Potter-Bucky diaphragm. We find that the negatives of the pelvis taken with this are very much clearer, and consequently capable of much more accurate measurement.

We are using a universal Coolidge tube at 9 inch parallel spark-gap at about 15 milliamperes, and find that fifteen seconds is a satisfactory exposure for moderate size pregnant abdomens.]

Fig. 5. Filter, Plumb-bob and Control Rod.

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PRESENT PROBLEMS AND FUTURE PROSPECTS OF DEEP ROENTGEN THERAPY*

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WITHIN the past year, one of America's distinguished physicists inquired of the writer whether the roentgen ray had any therapeutic action on tissues other than the skin. This question, propounded in all seriousness by an acknowledged expert in *x*-ray physics, if accepted as indicative of a general lack of knowledge of this work, reflects rather discreditably upon those of us who have been endeavoring to set forth the doctrine of deep roentgen therapy. We have failed either to present tangible facts in convincing form through the medical press, or we have written too much at random and with so apparent a lack of unanimity of opinion as to disqualify our claims.

For some reason, *x*-ray therapy has not kept abreast of diagnosis, and unless we arrive at a certain stage of unification and standardization of the former our efforts will not bear the fruit they should. With this purpose in mind, a brief survey of some phases of this work may be of value. Since it is generally admitted that in certain limited diseases of the skin and appendages, the *x*-ray is an undisputed dominating factor, we shall confine our attention in this discussion to the present day accomplishment of so-called deep roentgen therapy. We shall also touch on what are, in our opinion, the most vital of the problems facing the *x*-ray operator to-day.

In the comparatively recent period in which short wave lengths of *x*-radiation have been produced in working quantities, a mass of valuable therapeutic data has been accumulated. With this as a basis, we can segregate the conditions in which favorable results may be expected, conditions which will uniformly show an end result varying

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14-17, 1920.

between more or less permanent relief and a clinical cure. As falling within this class, we may roughly enumerate certain glandular and organic diseases. Named in the order of their responsiveness, we would mention localized adenopathies, simple post-infectious, and tubercular. From this list, we are excluding luetic and carcinomatous glands. Next in order are diseases of metabolism due to hypo- and hyper-secretion, those involving the thyroid, thymus, adrenals, and, according to more recent investigations, the pituitary. Hyper-activity of the ovary is very readily influenced and corrected by deep roentgen therapy. The same influence can easily be obtained upon uterine cells, particularly where menorrhagia is a sequence. Fibromata and myomata show a uniformly favorable response in a manner to convince the most skeptical. In the spleen and its associated leukemias we have a stay of the pathological blood changes sufficient to make the effort distinctly worth while. The list of conditions enumerated may be said roughly to include the present day indications for deep roentgen therapy in so far as clinical relief may be expected, and for which up to the present time no other more useful medical agent has been found.

The question will of course be raised: In the malignant forms of internal disease, has the *x*-ray any action which will warrant its use? From a careful perusal of the literature, and a knowledge of the work of many conscientious radiologists, as well as from our own experience, which has extended over a period of many years, we have reached the conclusion that in certain types of internal malignancies roentgen therapy has achieved some success. This is particularly true in carcinomatous glands. Those due to an extension of a malignant process respond more favorably than those due to a true metastasis. Our failure to influence carcinomatous masses has been largely due to our inability to deliver to any particular deep area a lethal dose. This is a problem which the future must solve. There are on record, however, a considerable number of cases of sarcoma, of which we have had several in our own practice, that have been clinically cured by deep roentgen therapy.

As is well known, in carcinoma of the deep tissues, we have had very little encouragement; yet the following case is so extraordinary that it is well worth recording. The patient, male, forty-two years old, with carcinoma involving the lower third of the stomach and the pylorus, inspected through abdominal incision, was declared inoperable and also pronounced malignant by every laboratory and clinical test. He had the usual signs of advanced pathology, pain, cachexia, and rapid loss of weight, and was referred for roentgen treatment as a placebo. The upper abdomen was subjected to intense *x*-ray exposures with heavy filters. In sixty days, the patient had gained twenty pounds, his color was better, his appetite and stomach function greatly improved. *X*-ray treatment has been continued for several months. Nearly a year has elapsed since the exploratory incision. At present, the tumor is no longer palpable, but the tissues on deep pressure feel fibroid and non-elastic. The patient's stomach functionates properly, he retains his normal weight, feels well, and maintains active work. The outlook is decidedly hopeful.

The present day problems of deep roentgen therapy have to deal largely with our ability to deliver a sufficient number of radio-active units to the tissues we wish to influence. With the instruments now available this is acomplished to a certain degree, but we are yet far removed from an ideal which will permit us to deliver at will a known quantity of the energy of radiation to a desired point. In deep roentgen therapy, our first aim is to deliver to the part sufficient radiation profoundly to influence this part, not, as is often the case, merely to a point of stimulation or irritation, but in sufficient force to cause a complete inhibition of pathological cell activity. From a theoretical stand-point, it would seem logical to assume that when a bundle of deeply acting rays pass through cellular tissues of widely differ-

ent construction and function, both normal and pathological, if such rays are delivered in quantity sufficient to inhibit the action of the pathological cells, the normal structures must suffer equally. Undoubtedly this is true to a degree, yet there is very little evidence that such destruction actually occurs. It must be remembered that we are not referring in these remarks to the European 16-hour technique or to *x*-ray necrosis with secondary destruction due to so-called burns associated with the skin and adjacent tissues. The writer has always assumed that in the soft cellular tissues of the body very little absorption of rays occurs, and that only in congested areas with cellular impaction are the rays absorbed sufficiently to give off the well-known secondary effects, which are the actual working units of ray energy. If this simple hypothesis is accepted it would easily explain why we get an apparent selective action on pathologic structures.

In our work, one of the most important of the problems is the thorough and effectual protection of the skin and its appendages. There is a healthy endeavor in this direction now evident, and our former two or three millimeters of aluminum are now replaced by six to ten millimeters of aluminum. This is highly desirable when working with one hundred kilovolts or more. Another phase of the same problem is the protection of the operator as well as of the patient. Under such high tension work, the patient is frequently better protected than the operator. The usual protective screens, which come as a part of the generating plant, are wholly inadequate. Lead one-half inch thick on three sides of the operator's booth is none too heavy. The lead glass windows in such a cabinet should be in layers to make a one inch thickness. It is doubtful whether any of us take this amount of precaution, but it is most certainly indicated.

Radiologists to-day have a fairly definite idea of what constitutes a safe massive dose, yet there is so great a difference in the technique of the various operators that a definite general formula cannot be adopted. A massive dose through ten millimeters of aluminum filter has an entirely different range of activity from one where four millimeters are employed with the same setting. Again, one using an eight inch focal distance and another ten, with otherwise the same formula, will fall far short of arriving at the same point. The greatest difference in the formulae, however, is in the kilovoltage constant. It is extremely difficult to maintain a consistent ten inch back-up with our present equipment, although this point should be striven for if we are to expect definite effects deep down in the tissues.

Gleanings from the field make it apparent that the average massive deep dose ranges in formulae as follows: Voltage or spark back-up equivalent from 7½ to 10 inches, focal distance 6 to 10 inches, filters 3 to 6 millimeters aluminum, milliamperes on tube circuit 4 to 6, time 5 to 10 minutes. From these various combinations, a very effective deep massive dose could be administered, and on the other hand one of no practical use whatever could also be chosen. In an attempt at standardization, the writer is now engaged in working on formulae based upon the distance beneath the surface we endeavor to reach. Briefly these are as follows: With 3 constants, back-up 10 inches, focal distance 8 inches, milliamperes 5, tissues up to 2 inches below the surface, 4 millimeters aluminum filter, time 7 minutes. This dose may be repeated twice within thirty days over the same skin area. Tissues 4 inches below the surface, 6 millimeters aluminum, time 10 minutes. This may be repeated over the same area twice up to thirty days. Parts 6 inches or more beneath skin, 10 millimeters aluminum, 15 minutes time. This dose may be repeated three times in thirty days. In all this work, an additional cotton filter, one-half inch thick, under compression, is employed. No further exposure is permitted over the same surface within three months.

The future prospects of deep therapy are distinctly encouraging. When we look back upon the comparatively few years in which

an effort has been made to separate the wheat from the chaff in x-ray therapy, we have strong reasons to be optimistic. No doubt certain improvements in apparatus will soon be developed: First, an electrical generator with unlimited voltage, so constructed as to render the patient's circuit free from danger; second, a controlling device calibrated with a selective system to give any range of penetrability desired; and third, a "Coolidge" tube of sufficient capacity to lend itself in every way to the requirements laid down. If such a development occurs in the not too distant future, the scope and success of deep roentgen therapy will be materially increased. Will such evolution of x-ray energy prove a definite cure for cancer? The writer believes not, but he also believes that it will be found in that case to be superior to surgery, and, combined with the latter, will probably be the best method of attack, until the true cause of this terrible disease of modern civilization has been found and conquered.

Addendum: Since this article was written, I am informed that American engineers are perfecting high voltage tubes and transformers of even greater capacity than those in foreign service, and that these will soon be available for our use. This eventuality, of course, will necessitate a complete reorganization of all our present treatment factors.

THE AUTHOR.

GENERAL DISCUSSION FOLLOWING SYMPOSIUM ON THERAPY

DR. G. E. PFAHLER. There has been so much material presented in these papers that it is impossible to discuss everything thoroughly. The work presented by Dr. Levin was of a fundamental character, and will give us principles to work on that do not need so much discussion.

The excellent results obtained by Dr. Hickey in the treatment of papillomata and carcinomata of the larynx are brilliant. You can get, however, good results, too, by the external application of radium or x-ray. I have had a patient with carcinoma of the larynx for approximately six years, treated by the x-ray alone, cross-firing as much as possible on the disease. I have used the intubation tube, adapted according to the case, for the introduction of the radium inside. The method Dr. Hickey has used of bringing the capsule up from below in the tracheotomy wound is very good. I had thought of doing that, but have never done it. I have a patient at the present time with a tracheotomy wound, and I may carry out that technique when I get home.

I was very much interested in the needle technique described by Dr. Boggs, and I am just as enthusiastic in that as he. I believe that by properly combining the radium with the x-ray, we can get more carcinomas of the breast well than by any other means or any other combination. I had a little experience with one case that has been to me most striking, and this patient seemed to be hopeless, even for radiumtherapy, when I started. The patient had been operated on a year before for carcinoma of the right breast. The patient was sent to me with an ulcerating recurrence in the scar, approximately two inches in diameter, with indurated extensions along the scar, and a nodule in the axilla of the operated side, perhaps an inch in diameter. The unoperated breast contained a tumor mass, a group of nodules extending up into the axilla, varying from a half inch to an inch. There was present, also, mediastinal infiltration, presumably carcinoma, extending outward into the lung area. You will admit that is a pretty bad picture. There were also numerous nodules in the supraclavicular region on the left side, which was the side not operated.

I introduced radium needles directly into the carcinoma of the breast and each of the nodules leading up into the axilla, and into the recurrent nodules in the opposite axilla. I made surface application of radium to the

nodules in the supraclavicular region, and I made surface application of the radium over the recurrence in the scar. Then I cross-fired with the x-ray into the mediastinum through numerous portals of entry. That was started in February. So far as we can see to-day, either by eye, by finger or by roentgenogram, that disease has disappeared. That is more of a result than I believed could have been obtained by a combination of x-ray and surgery.

I have used radium needles in some other cases of carcinoma of the breast, but they were of a kind that might have gotten well by other means. I believe this case probably would not have recovered, although I have had some striking results even with the x-ray alone, but I am convinced that where you can bring the radium in direct contact with the part, either by direct surface application over a nodule or by introduction of the needle into the disease, you get more pronounced and startling results than by x-ray application. It may be because we are using more secondary rays that we get the more pronounced results. However, for the treatment of general surface, or for treatment into the mediastinum, you will get better results by the roentgen rays.

Dr. Kennon Dunham. I should like to ask Dr. Pfahler what are the sizes of the areas of cross-firing in the mediastinum. How large an area can be treated with the x-ray?

Dr. G. E. Pfahler (Answering Dr. Dunham). About three inches square. I would like to add a word about cross-firing. I see a great deal of marking up of the chest and cross-firing. Unless you can make that portal of entry bring about an actual cross-fire, you might as well treat two, three or four areas at a time. You must decide, first of all, as near as you can, where your tumor is, and then all your rays should be passed through that tumor area. You ought to arrange the position of your tube, etc., so that your rays go through the tumor. The doctor can do better x-ray therapy than the technician, because he is supposed to know anatomy and he is supposed to know pathology, and he is supposed to know where the disease is, etc. It should be his business in each instance to direct his treatment toward that disease.

Dr. George C. Johnston. The statement Dr. Pfahler has just made in regard to cross-firing and the necessity of aiming accurately in the direction of the tumor is, of course, correct, but I would take considerable issue with the statement that radiation directed toward a solid body, such as a patient, even if not directed in the proper axis, would have no effect. It has been well established, I believe, that all the therapeutic effect you get from x-ray radiation is due to secondary radiation in the tissue, so it wouldn't make so very much difference if the rays were directed absolutely or not in the proper mathematical direction. I have never been able to convince myself that the filtered gamma rays from radium were directly able to do very much. It is in all probability the secondary radiation set up which has the effect, and the same is true of the highly penetrating x-rays. Why do we get so much more effect when we use a highly filtered x-radiation with correspondingly less length of application? It may be that it is due to the secondary radiation.

Now, we know that the very radiation that is therapeutically effective is radiographically outlawed. We know that the secondary rays will produce a foggy plate, but these are the rays which are therapeutically effective. Did you ever think about that?

Dr. W. C. Alvarez. I would like to call attention at this point to some ideas again from those worms I talked about yesterday. To my mind, some of the most stimulating work done on the cancer problem has been done by a zoologist, Professor Child. If you wish to get a new outlook on the cancer problem, I would suggest that you read his book on "Senescence and Rejuvenescence" published by the University of Chicago in 1915. There he shows how the original embryonic cells are undifferentiated, that is, they are all about alike and all have the capacity for rapid growth. Later, as they differentiate and take on special functions, they fill up with material which he calls metaplasm. This more or less fixed and dead material increases in amount as the cells grow older; and with its increase, they lose their original power of growth and multiplication.

Finally, a time comes when the cell develops the power of eating up the metaplasm, it de-differentiates, and in so doing regains its original power of rapid growth and fission.

This method of rejuvenescence is naturally of great value to lower organisms, but it constitutes a great menace to the higher animals. I believe that a careful study of this mechanism in the lower organisms may help us greatly in finding the cause and cure of cancer.

The idea of a metabolic gradient comes in in the treatment of cancer. The rapidly growing tumor cells probably have a fast metabolic rate and a large demand for oxygen. We have seen that such rapidly growing tissues suffer more from some poisons than do tissues of slow growth; and the problem of cancer cure, as I see it, is to find some substance which will damage the rapidly growing cells and leave intact the more slowly growing ones of the host. In working towards this end, it would be very helpful to know exactly what the rates of metabolism are in the different parts of the body and in the tumors.

Some of you have asked me for suggestions as to the causes of nausea after roentgen ray treatments. I will say that in the Hooper Foundation, my chief, Dr. Whipple, and some of his associates have been giving large dosages over the abdomens of dogs, and they have found that they can produce deep ulcers in the mucous membrane of the stomach and intestine. If the cone used is a small one the ulcers are small and their edges are sharply limited. If such lesions are produced in man they may account for some of the digestive upsets seen after roentgen ray treatment.

Dr. W. S. Lawrence. I would like to hear a little discussion on the matter of equivalent filtration. This is what brought the thought to my mind. Someone in a paper yesterday said he was using one millimeter of copper and that one millimeter of copper was equivalent to 19 mm. of aluminum. Now if that is true, I would like to know it. Roentgen, in his original paper, stated that the *x*-ray penetrates all materials in proportion to their specific gravity. I do not know that that law has ever been proven false. Now copper is only about three times as heavy as aluminum, and three or four millimeters of aluminum ought to be equivalent to one millimeter of copper.

One other point I would like to suggest: In treating a widespread involvement like the case Dr. Pfahler mentioned, of carcinoma involving practically the whole thorax, and particularly where the lungs are involved, I think the distance method over a large area is a much more valuable method of application than the method of blocking off in small areas, because, as Dr. Pfahler said, in small areas improperly directed, the part below will not get the required amount. Although there is a difference of rays which gives you some cross-fire, even though you direct the central rays at right angles, still the part below the center of one of those areas would get only about what the skin would stand at six or eight inches, according to the distance you select. But if you get twenty inches from the part, and hit a large area, then the part below will get nearly as much as the skin and the effect will be much greater and incidentally you save a great deal of time.

Dr. A. L. Gray. I didn't hear all of Dr. Hickey's paper, but many of the members will recall that at the meeting in Niagara, I reported four cases of laryngeal papillomata treated by the *x*-ray with almost complete success in all four of them. I have since added two adult cases. I would like to know from Dr. Hickey how long he treated this case, and how long he waited after the treatment? My experience with cross-fire radiation in laryngeal papillomata, non-malignant, has been very satisfactory.

Dr. P. M. Hickey. In reply to Dr. Gray's statement, I will state that I waited between three and four years. She had treatments extending over three months, and was also treated elsewhere by the *x*-ray. I tried to bring out in the paper that, from a clinical standpoint, there are two kinds of laryngeal papillomata, one of which is very amenable to surgical treatment, and the treatment I suggested is simply for those intractable cases of papillomata of the larynx. A certain number are very amenable to surgical treatment, and evidently, from the Doctor's remark, to roentgen treatment, also. There is, however, another class which tends to recur very persistently and it is in that class I suggested the contact application of radium to the papillomatous masses.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M. D., *Editor* · Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D. C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

SIXTH ANNUAL MEETING THE AMERICAN RADIUM SOCIETY

BOSTON, JUNE 6 AND 7, 1921. HEADQUARTERS, HOTEL BRUNSWICK

WASHINGTON MEETING

The Twenty-second Annual Meeting of The American Roentgen Ray Society will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits, will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of The American Roentgen Ray Society. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person,	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

PRELIMINARY ANNOUNCEMENTS

Dr. A. C. Christie, President of the Society, announces that plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. Réné Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers on therapy than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will

enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it necessary to atend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

A. C. Christie.

WESTERN SECTION

The American Roentgen Ray Society

The second annual meeting of the Western Section of The American Roentgen Ray Society will be held at Portland, Oregon, May 27th and 28th, 1921. The headquarters will be at the Portland Hotel, and the Chairman of the Local Committee on Arrangements is Dr. Roy A. Payne, Stevens Building.

Every facility will be provided for the demonstration of plates and slides. On Friday afternoon time will be taken for an automobile trip over the famous Highway, and the banquet will be held on Friday night, May 27th.

The National Society has been requested to send President Christie to the meeting, and it is hoped that he will be present. One day of the meeting will be occupied by the Western Section of The American Roentgen Ray Society, and the other day by the Pacific Coast Roentgen Ray Society. The following papers have already been promised for the Western Section program:

Super-radiation and Delayed Reactions; Albert Soiland, M.D., Los Angeles.

Postural Variations in Cecum and Colon and their Interpretation; Roy A. Payne, M.D., Portland, Oregon.

Fractured Vertebrae; William B. Bowman, M.D., Los Angeles.

Treatment of Leukemia; H. B. Thompson, M.D., Seattle.

Subject to be announced; Dr. Charles M. Ruggles, San Francisco.

Subject to be announced; Dr. Charles M. Richards, San Jose.

The Pacific Coast Society will have several papers of interest in their Section, and the meeting promises to be very successful.

W. Warner Watkins, Secretary.

BOOK REVIEWS

Grenzen des Normalen und Anfaenge des Pathologischen im Roentgenbilde. By Prof. Doctor Alban Köhler, Wiesbaden. Third Edition, revised and enlarged. xi + 415 pages. Illustrated. Published by Lucas Gräfe and Sillem, Hamburg.

It has been a distinct pleasure to review the third edition of Dr. Köhler's book which appeared in May, 1920.

This edition has been enlarged by nearly one third. As it was impossible for Dr. Köhler, during the period of the war, to have access to the medical literature of the world, the revision represents almost entirely the results of his own investigations and experience. There are 415 pages of text introduced by a general part of eleven pages. All sections of the edition have been more or less enlarged, important additions having been made to the general section and the sections dealing with the cardiovascular system, the osseous system and pneumatic cavities. Attention is given to the outlining of growing bone, to inconstant parts of the skeleton, islands in the compacta, general disturbances of growth and to a great number of minor conditions of the skeleton. These are thoroughly described in 238 pages. Sixty pages are devoted to the thorax and 105 to the abdomen. Concerning the gastro-intestinal tract there has been no change made beyond that contained in the second edition. There is a complete index and an extensive bibliography.

The author, in his preface to this edition, calls attention to the illustrations which are tracings of the original roentgenograms, exact to the millimeter, and mechanically reduced in the Academy of Arts. These tracings are excellent in their simplicity without undue elaboration and consequently reveal at a glance the normal condition or lesion they are intended to illustrate.

The object of Dr. Köhler's book is concisely summarized in the title. Its value lies mainly in its descriptions of early pathologic changes and its demonstrations of the wide variations which may exist within normal limits and which are a constant source of error in the interpretation of roentgenograms. Typical lesions have been described and pictured often enough; the great difficulty lies in making accurate diagnoses of early pathologic changes, in view of these wide limits of normal variation.

This excellent discussion of normal and early pathologic processes should be carefully studied by every physician contemplating the study of roentgenology, and even the expert would profit by carefully reading this work, for it presents the very foundation upon which interpretation rests.

R. D. Carman.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, H. M. Imboden, M.D., New York

VOL. VIII (NEW SERIES) JUNE, 1921 No. 6

THE RELATION OF THE SCIENCE OF PHYSICS TO RADIATION THERAPY*

By HENRY SCHMITZ, A.M., M.D., F.A.C.S.

CHICAGO, ILLINOIS

THE honor you bestowed upon me at the last annual session of the AMERICAN RADIUM SOCIETY by election to the presidency was not expected and was reluctantly accepted. I was aware of the many duties the office would bring and my inability to do justice to its proper representation. The year was hardly on its way, when the various officers and committees began to make preparation for the 1921 session. I observed with a great deal of satisfaction that my office was hardly on its way when the various officers and members of committees had actually incurred a goodly amount of work. It is to their efforts that the sixth annual meeting has been such a great success, and that the scientific part of the program equals that of the preceding meetings. Harvard University, one of the most renowned seats of learning in the world, magnanimously responded to our request for active participation in the scientific proceedings and Dr. Robert Greenough has consented to give a clinic at the Huntington Memorial Hospital to demonstrate the rapid strides radiation therapy is making. I am certain to voice your sentiment in extending to Dr. Greenough and his coworkers, to the officers and committees, the deep-felt thanks and gratitude of our Society. Permit me, also, to take this opportunity to thank you for the honor you have conferred in electing me to the presiding office for the sixth annual session.

Radium therapy and the sister science *x*-ray therapy are entering upon a new era. Empiricism and uncertainty in the therapeutic application of radiation are being rapidly replaced by scientifically correct methods. A biological unit of dose has been defined, measuring instruments have been perfected accurately to gauge the dose, and clinical investigations have progressed so far that lethal dosages for normal and abnormal tissues have been established. Laboratory researches have been continued to investigate the influence of radiations on the blood and blood-forming organs, to interpret correctly radiation sickness or toxemia and to explain their influence on the prognosis of radiation therapy. Much of the progress would not have been made had not the sciences of chemistry and physics and medicine worked hand in hand. History repeats itself. Roentgen, the physicist, discovered the *x*-ray. Madame Curie, the chemist, extracted radium, after Henri Becquerel had detected

*Presidential Address delivered at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, at Boston, June 6, 1921.

radio-activity in uranium ores. Scientists and physicians have since labored unceasingly to evolve correct methods of technique and establish laws of indications and contra-indications for the medicinal applications of radiations. The fact that a solution of the many problems of radiation therapy can be reached only by the joint labor of chemist, physicist and physician has been recognized by our Society from the beginning. We are, indeed, fortunate to count among our members the foremost chemists and physicists of our country.

During the last year I had the opportunity to observe the radiation investigations done in England, France and Central Europe. Of all the various researches carried on I deem those the most important which are concerned with the measurement of radiation. Permit me, therefore, to explain them in detail.

In 1914, B. Szilard of Paris devised an electrometer that was standardized to measure radiation units of uranium. With the instrument it was also possible to measure directly gamma radiations of radium from 1/100 milligram to 500 milligrams without time-consuming calculations. A deflection of the hand of the electrometer indicates the amount of gamma radiation of a radio-active preparation subjected to measurement. W. Friedrich of the Freiburg University perfected an instrument, which is composed of an electrometer and an ionization chamber of 1 c.c. volume. The latter is attached to the electrometer or may be attached to any electroscope by a dielectric cable of any desired length. The ionization chamber is not larger than an ordinary F.30 sound. The advantage of the modification of Szilard's electrometer consists in the possibility of inserting the measuring chamber into body cavities and water phantoms and thus measuring the radiation intensities actually obtained at the seat of the lesion.

TABLE I

Measurements of a 50 mg. Radium Element Capsule. Length 2.28 cm., Filter 1.5 mm. Brass and 5 mm. Celluloid.

a. In Water

Distance in cm.	*Measured Doses in % of Dose at 1 cm. distance*	*Doses Calculated from Absorption and Distance*	*Differences in % of the Calculated Doses*
1	100.		0.
2	23.2	22.5	3.1
3	10.4	9.0	15.6
4	5.4	4.55	18.7
5	3.3	2.62	25.9
6	2.2	1.64	34.1
8	1.2	0.72	66.6
10	0.7	0.39	79.5

b. In Air

1	100.	100.	
2	25.	25.	
3	11.2	11.1	
4	6.0	6.3	
5	4.0	4.0	
6	2.6	2.8	
8	1.4	1.5	
10	1.0	1.0	

Connecting the ionization chamber with a Wilson electroscope Friedrich was able to measure the intensities of radiations at various distances from the source. The measurements were made with a preparation of

mesothorium equalling 46.46 radium element gamma radiation and enclosed in a silver capsule of a diameter of 4.6 mm. and a length of 2.28 cm. It was placed in a brass filter of 1.5 mm. wall thickness and surrounded by a celluloid tube of 5 mm. wall thickness to arrest the Sagnac rays effectually. The measurements were taken in water and air and compared with the calculated dose. The differences in the percentages of the measured and calculated doses and those taken in water and air are due to the secondary radiations formed in water. Since the secondary radiations in water are practically of the same value as those in the human body, the deductions apply equally to both. (See Table I.)

In the treatment of diseases it is often feasible to use much larger amounts of radium. Therefore several capsules were placed in filter tubes in a so-called tandem formation. Measurements of such an arrangement showed more or less marked deviations from the values obtained from the single capsule. These mesothorium capsules, each of a radium element content of about 50 mg. and a length of about 3 cm., were placed in a brass filter tube of a length of 8.28 cm. and wall thickness of 1.5 cm., surrounded with a celluloid tube of a wall thickness of 5 mm. The measurements were taken at various distances in a vertical direction from the center of the longitudinal axis in water as well as in air. The results are shown in Table II.

TABLE II

Measurements of Three 50 mg. Radium Element Capsules. Length 2.25 cm., Filter 1.5 mm. Brass and 5 mm. Celluloid.

a. In Water

Distance in cm.	*Measured Doses in % of Dose at 1 cm. distance*	*Doses Calculated from Absorption and Distance*	*Differences in % of the Calculated Doses*
1	100.	100.	0.
2	32.4	22.5	44.0
3	15.7	9.0	74.5
4	9.3	4.55	104.5
5	5.6	2.62	113.5
6	4.2	1.64	156.0
8	2.4	0.72	233.5
10	1.5	0.39	285.0

b. In Air

Distance in cm.	*Measured Doses in % of Dose at 1 cm. distance*	*Doses Calculated from Absorption and Distance*	*Differences in % of the Calculated Doses*
1	100.		0.
2	30.5	25.0	22.0
3	15.0	11.1	34.9
4	9.3	6.3	48.8
5	6.3	4.0	57.6
6	4.6	2.8	67.0
8	2.6	1.5	66.5
10	1.6	1.0	60.0

If the source of radiation be a point or ball-like body of equal dimensions all around, then the planes of like doses, termed standard or isodoses by Friedrich, surround the source of radiation concentrically. The radium tubes which we use in deep therapy are of a cylindrical shape. One might assume that the planes of isodoses would form parallel with and cylindrically around the tubes. However, if actual measurements are taken in water for both preparations, that is, the one tube and three tube arrangements, the results of the measurements as given in Tables III and IV are obtained.

Having made these determinations Fried-

TABLE III

Measurements of 50 mg. Radium Element Capsule. Length 2.28 cm.

Distance in cm.	*Doses Measured in Center Vertically to Long Axis*	*Doses Measured at End Vertically to Long Axis*	*Doses Measured in Direction of Longitudinal Axis*
1	100.0	70.	25.
2	23.2	20.	9.4
3	10.4	9.0	5.0
4	5.4	5.0	3.2
5	3.3	3.1	2.1
6	2.2	1.9	1.4
8	1.2	0.9	0.8
10	0.7	0.5	0.5

TABLE IV

Measurements of Three 50 mg. Radium Element Capsules. Length 8.25 cm.

Distance in cm.	*Doses Measured in Center Vertically to Long Axis*	*Doses Measured Vertically to Long Axis Midway Between Center and End*	*Doses Measured at End Vertically to long Axis*	*Doses Measured at End in Direction of Long Axis*
1	100.	61.5	36.4	19.5
2	32.4	22.7	14.7	7.8
3	15.7	11.7	8.9	4.5
4	9.3	7.4	5.4	2.8
5	5.6	4.9	3.9	2.2
6	4.2	3.1	3.0	1.6
8	2.4	1.8	2.0	1.0
10	1.5	1.3	1.3	0.4

rich could now proceed to ascertain the isodoses for radium preparations of the same length, i.e., 2.28 and 8.28 cm. If the radiation intensity is assumed to be 100 per cent at a distance of 1 cm. in an axis drawn vertically to the center of the longitudinal axis, then the percentages 90, 80, 70, 60, 50, 40, 30, 20, 10, 5 and 2 give the curves for isodoses, as seen in Figures 1 and 2 below.

Thus we gain from the researches of a physicist a correct idea of the actual intensities of radiations. The therapeutic application of these values has been worked out by

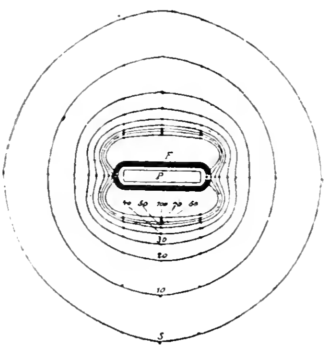


Fig. 1. Curves of Isodoses of a Radium Capsule of a length of about 3 cm. [Friedrich].

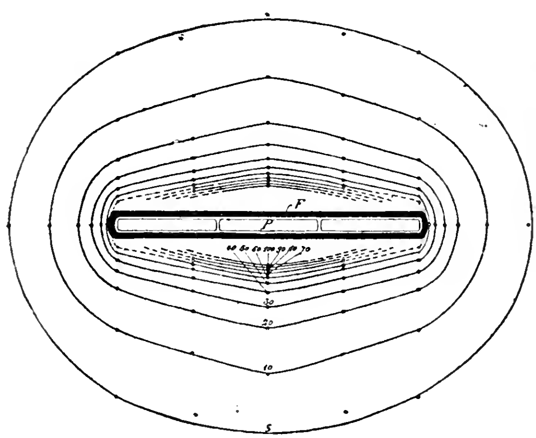


Fig. 2. Curves of Isodoses of Three Radium Capsules of a total length of about 9 cm. [Friedrich].

Opitz and Friedrich. The iontometer expresses radiation values in electrostatic units, shortly designated by a small "e." If a capsule of radium containing 30 mg. element filtered through 1.5 mm. of brass and 5 mm. of celluloid is applied to the skin at a distance of 1.5 cm. the application to produce necrosis of the skin must be extended to seventy hours, i.e., 2100 mg. e hrs. This measures 300 e. Hence 7 mg. e hrs. would equal 1 e.

If we refer to the tables and figures of isodoses, we see that, if a 50 mg. radium element capsule be used, the dosages at various distances for an hour's application are as shown in Table V.

TABLE V

Isodoses for Various Distances and Time Durations.

Distance in Cm.	*% of Isodoses*	*% of E.S.D. of 50 mg. Ra. El.*	*% of "e" Units*
1.5	40	100	14.2
2.3	20	50	7.1
3.4		25	3.55
4.7	5	12.5	1.78
5.6	2	5	0.71

	Exposure of						
Distance in Cm.	*10 Hrs.*	*20 Hrs*	*30 Hrs.*	*40 Hrs.*	*50 Hrs.*	*60 Hrs.*	*70 Hrs.*
1.5	71.0	142.0	213.0	284.0	355.0	426.0	497.0
2.3	35.5	17.0	106.5	71.0	177.5	213.0	248.5
3.4	17.75	35.5	53.25	142.0	88.75	116.5	114.25
4.7	8.9	17.8	26.7	35.6	44.50	53.4	62.30
5.6	3.55	7.1	10.65	14.2	17.75	21.3	24.85

Let us apply these observations to a practical example, for instance a cervical cancer.

The limits of the diseased area in cases that can be considered to be benefited by radiations are identical with the lateral bony pelvic walls, the pelvic inlet above, the pelvic outlet below. The axis of the cervix lies in the axis of the true pelvis. The uterus, adnexa and regional lymph glands are contained within the true pelvic cavity. The antero-posterior and transverse diameters measure 12 and 13 cm. respectively. A radium capsule of 50 mg. element will therefore give isodoses as indicated above and we at once know the exact intensities that may be obtained in any part of the true pelvis.

The question arises, How may we apply these results in therapy? Obviously a biologic unit of dose must first be ascertained that may be exactly reproduced by any one using radiations; secondly, comparative doses of normal and abnormal tissues must be determined and expressed in a known quantity.

The normal skin reacts to a dose of 160 to 170 e, with a mild inflammatory change characterized by the appearance within eight to ten days following radiation of an erythema and subsequent desquamation, and after three to four weeks by epilation and brownish discoloration of the skin area. This reaction has been termed an erythema dose (abbreviated E.S.D.). It is the standard of comparison for all other tissues and radiation reactions. A destructive reaction seen as blistering and subsequent necrosis of the skin is obtained with a radiation dose of 300 e, and is known as the death skin dose. It is, therefore, produced by about twice a dose of the E.S.D.

A radiation of the ovaries to produce amenorrhea is produced by 33 e; a cancer

dose to cause visible and palpable resorption of the tumor and local healing within six to eight weeks by 150 e. The erythema dose for the rectal mucosa appears to be 200 e, for the mucosa of the urinary bladder about 200 e. The sarcoma dose is 120 e, the muscle tissue dose 300 e, and the tuberculosis dose 100 e (Seitz and Wintz, Opitz and Friedrich).

The object of the radiation of uterine cancer is to cause degeneration or death of all carcinoma cells contained within the true bony pelvis without causing irreparable injury of the vital structures and organs within this area. If we refer to Figure 3 we see that the rectal mucosa receives an isodose of 10 per cent, while the bladder mucosa lies within the isodose of 20 per cent. Hence we must not extend the application of 50 mg. of radium element to more than fifty consecutive hours, otherwise the bladder will be severely damaged. The dose obtained at the bony pelvic periphery is, however, so minimal (17.75 e) that instead of arresting the growth of the cancer in this location, the rays will stimulate the cancer. The conclusion must be drawn that we can never apply a sufficiently large dose of radiation that will be lethal beyond a distance of 3 cm. if we wish to avoid irreparable injury to rectum or bladder.

Various procedures have been advised to overcome this deficiency, such as longer continued intra-uterine radiations irrespective of any detrimental consequences to rectum and bladder, the insertion of needles or trochars containing radium into the parametria, the application of radium packs containing up to one gram of radium element over the suprapubic regions, and the roentgen ray. It is obvious that the solution of the problem must be one that may be used in every hamlet of our country. We must strive to enable as many cancer patients as possible to obtain the benefits of radium treatment. Roentgen laboratories are connected with almost all hospitals. Fifty or one hundred milligrams radium element could easily be obtained by a group of interested medical men.

May a combination of radium and roentgen ray therapy improve the outlook for the the patient? Again the physicists are showing us how to proceed. Coolidge and his associates, the large European clinics, with the

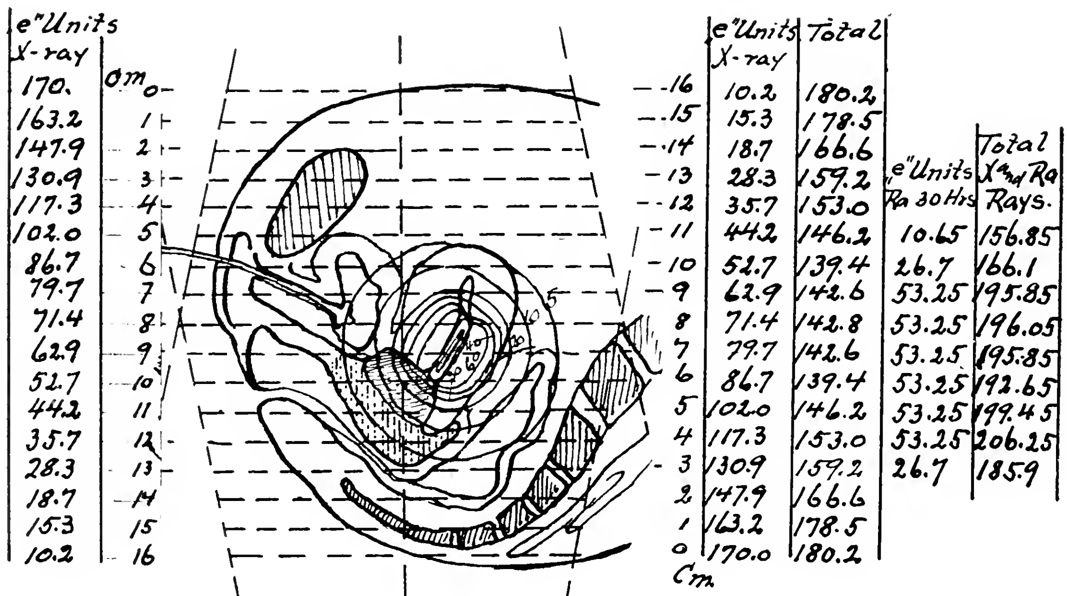


Fig. 3. Median Longitudinal Section of Pelvis showing the Intensities of X-rays for each Centimeter and the Isodoses of the Radium Capsule Inserted into the Uterine Canal. [After Opitz and Friedrich.]

cooperation of physicists such as Friedrich at Freiburg, Wintz and Voltz at Erlangen, Item at Berne, have measured the absorption curves for the different qualities of x-rays.

Through the kindness of Dr. Coolidge and the Victor X-Ray Corporation I have been supplied with a measuring instrument. By means of it I have made actual measurements in the living subject. The values obtained are shown in Figure 3. The clinical application of the x-ray is performed as follows:

An exact median longitudinal section is made measuring the distance from the anterior body surface to the posterior surface and from the anterior surface to the cervix and from the posterior surface to the cervix, as seen in Figure 3. Lines 1 centimeter distant are drawn across. The x-ray intensities are entered for each centimeter, to the left those obtained through the anterior portal of entrance, to the right those through the posterior portal of entrance. A summation of both is entered in the second column to the right. It will thus be seen that the radiation intensities between the fourth and twelfth centimeters lack intensity values of 20 to 30 e, 170 e being the required and permissible intensity. A thirty hours' application of fifty milligrams radium element will increase the deficient intensities as follows:

At 5 cm.	146.2 + 10.65	= 156.85
At 6 cm.	139.4 + 26.7	= 166.1
At 7 cm.	142.8 + 53.25	= 195.85
At 8 cm.	142.8 + 142.0	= 284.8
At 9 cm.	142.8 + 284.0	= 426.8
At 10 cm.	139.4 + 142.25	= 285.65
At 11 cm.	146.2 + 106.5	= 252.2
At 12 cm.	153.0 + 53.25	= 206.25
At 13 cm.	159.2 + 10.65	= 169.85

At the anterior rectal wall the intensity is $146.2 + 53.25 = 199.45$, at the fundus of the urinary bladder $142.8 + 53.25 = 196.05$. It is seen, therefore, that the lethal dose has not been exceeded at these organs except within the limits of the uterus. This organ will become destroyed.

The exhaustive researches on radiation intensities carried on by the physicists have enabled the clinician to work out a technique that conforms to the most important requirement of cancer therapy, namely, the carcinoma must be traversed by a homogeneous radiation intensity that can cause all the cancer elements to degenerate without doing irreparable damage to the vital structures contained within this area. The future will tell us whether by this technique the prognosis of the cancer disease will be improved. The primary results obtained are better than those from the sole use of radium.

The object of the presentation of these investigations is to induce the members of the Society to carry on researches along the same line. Without the collaboration of the physicist it will be almost impossible. The empirical methods of stating radium dosage in milligram element hours and x-ray dosage in milliampere minutes, the practice of calculating the dose from the laws of absorption and distance without considering secondary radiations, are obsolete and unscientific. Whether the biological reaction of the secondary radiation equals that of the primary x-ray and gamma ray radiation is also a disputed question.

In perfecting the technique of radiation therapy we must not overlook other equally important questions that await classification and solution, such, for example, as further histological evidence of the changes in radiated tissues, which will solve the much-debated question of the supposed differences in sensitiveness to radiations of cancers of different cell structures; the reaction of the blood and blood-forming organs and the metabolic disturbances in radiated patients. Finally the study of the nature of the toxemia or radiation sickness must be investigated to establish its value either as a contributive curative or as a detrimental factor to the patient's chances of recovery. The problems are many. Yet the evident desire for investigation shown by all the members of this Society will lead to an early solution of these interesting problems.

X-RAY TREATMENT OF HYPERTROPHY OF THE PROSTATE*

By SAMUEL STERN, M.D.

Radiotherapist to Mount Sinai Hospital, and Chief of the Radiotherapy Department of the Mount Sinai Dispensary

NEW YORK CITY

X-RAY therapy of hypertrophy of the prostate gland has been carried out for a number of years. The reports that have appeared in medical literature from time to time, so far as the results are concerned, have not been very enthusiastic. They all agreed that it had a beneficial influence upon the prostatic bleeding and pain, and upon the frequency of micturition, but they thought that it had very little if any influence upon the size of the prostate and upon the amount of residual urine. They considered the treatment as chiefly indicated in the early cases, during the waiting period, and that all it may accomplish is to make these patients a little more comfortable until they reach the stage where operation would become imperative.

I think this is entirely too pessimistic a view of the situation. At least I feel that the results accomplished in a number of cases which have been under observation for five or more years justify the belief that in many instances we can do better than merely expect a temporary relief from the more distressing symptoms.

For instance: One of my patients, a man sixty-six years old at the time he was referred to me, six years ago, was advised to have an immediate operation. He had a fairly large sized prostate which gave considerable annoyance in the form of pain and very frequent micturation. Under *x*-ray treatment these symptoms disappeared promptly and have not returned up to date. He is now seventy-two years old and, so far as symptoms are concerned he is not aware of the fact that he has a prostate. Examination shows the prostate to be still enlarged, but it feels softer and is much less sensitive. In the case of a physician who was referred to me five and a half years ago at the age of sixty-four with a large prostate and the accompanying pressure symptoms, with occasional difficulty in starting micturition, the results have been equally good. He assures me that he has not the slightest trouble and that his nights are practically undisturbed. In another case referred to me five years ago at the age of sixty-seven, the patient was on the waiting list for admission to the hospital to be operated upon. His general condition was rather poor, and the surgeon was reluctant to operate, but thought it the only chance of relief. This patient had some prostatic bleeding and a great deal of discomfort and pain. These symptoms yielded promptly and the patient has not the slightest prostatic annoyance to-day.

FIG. 1. Lead glass speculum with opening to fit over prostate.

Whether there is a real diminution of the size of the prostatic gland of these patients, or whether there is merely a subsidence of the chronic inflammatory condition accompanying the hypertrophy, is very difficult to determine.

In most cases there is a softening, diminished sensitiveness, and a diminution of the size of the prostate palpable, but all this may be readily explained by the subsidence of the inflammation. After all, probably with advancing years a certain amount of hypertrophy of the prostate is physiological and it is perhaps the accompanying chronic inflammatory condition that is responsible for most of the symptoms. Consequently if we

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

can through *x*-ray treatment influence this condition, we are in a position to do a great deal for these patients.

Knowing the effect of the rays upon glandular tissue, it is difficult to see why there should not be an actual diminution of the gland itself, and I feel quite sure that there must be. We know with certainty that in myoma, which is practically the same type of tissue as that found in these adenomas, there is a diminution, even to the extent of disappearance at times. At any rate, I have found that the majority of cases in which *x*-ray treatment was begun before the condition was too far advanced have progressed well and have escaped operation.

Choice of Cases.—The most favorable cases for *x*-ray treatment are the early ones, those that come to the physician complaining of occasional pain and discomfort in the prostatic region, with frequent micturition, possibly with slowness in beginning micturition or prostatic bleeding. Cases that are far advanced—those that have already entered the catheter life—have not done well. We may improve their subjective symptoms but I have not been able to get them to resume voluntary micturition. After they reach the stage of regular periodical catheterization they have learned to depend on this entirely, and either through a mental hazard or on account of paralysis of the bladder muscle they do not seem to be able to resume their normal function even if the prostate becomes softer and the inflammatory condition is relieved. Cases that are complicated with cystitis are not improved until that condition is treated in the usual way.

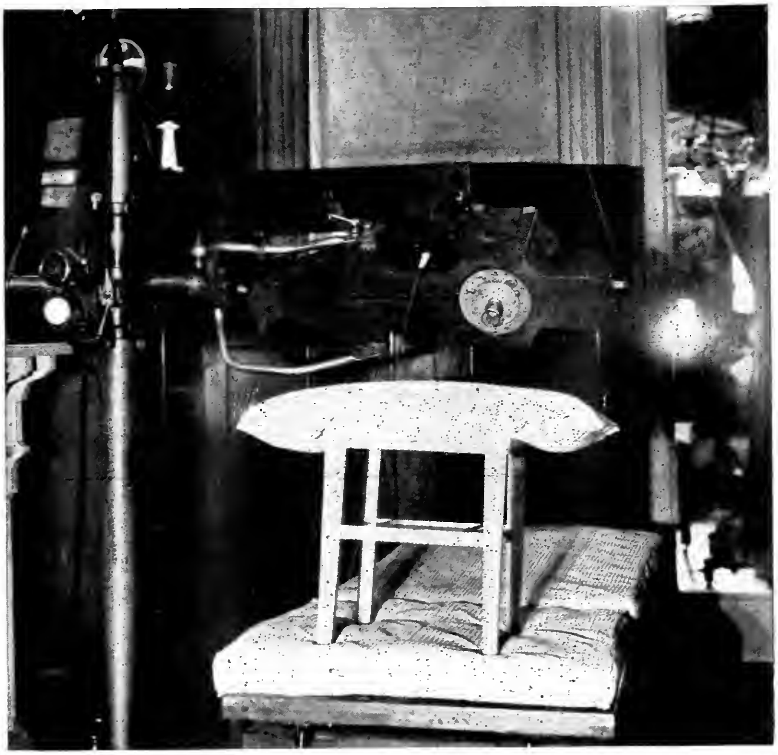


FIG. 2. Inclined tube-stand with lead glass attachment into which end of speculum fits.

Technique.—This is very important. The results depend entirely upon the proper application of the rays. The method I have used in treating my cases is as follows:

As port of entry, I use the rectum, with direct application upon the prostate and the

perineum. The patients are put in the knee-chest position. A blind pouched lead glass tube (Fig. 1), with an opening to fit over the prostate, is inserted into the rectum. The tube is covered with a thin rubber finger cot to prevent the edges from injuring the mucous membrane.

The tube-stand, with the proper filters in position and a small lead glass tube attached (Fig. 2) is now approximated to the lead glass speculum so as to make a continuous channel (Fig. 3).

The stand is tilted so that the rays will strike the prostate at a direct angle. Care is taken that as the speculum is inserted at each treatment the oval opening is applied over a different lobe of the prostate.

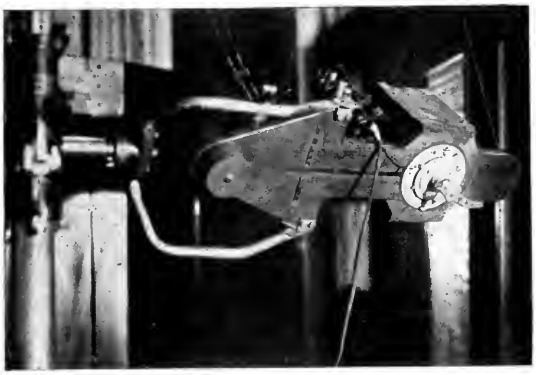


Fig. 3. Inclined tube-stand with lead glass speculum approximated.

In treating through the perineum, the small lead glass tube on the stand is put in direct contact with the perineum.

Dosage.—These patients are treated in series. Four weekly applications to the prostate and perineum are considered as one series. This is followed by an interval of one month, when the second series is given.

If there is a marked improvement at the end of the second series, the interval of rest is prolonged to two months before the third series is given. If not, it is given at the end of one month.

After three series have been given the interval of rest between applications should be at least two months. The number of series will depend upon the results accomplished. As a rule, there should be a decided improvement at the end of three series. If there is no change in the patient's condition at the end of this time, it is probably useless to continue with further treatments.

After the symptoms have subsided and the patients have been made thoroughly comfortable, the treatments are discontinued, but as a prophylactic measure I have found a great deal of benefit in giving these patients one series of treatments at intervals of six months over an indefinite period. This is undoubtedly worth while, and if your patients belong to the intelligent classes they will gladly submit to it. They have such a wholesome fear of the recurrence of their discomfort and of the possibility of an operation becoming necessary, that they will rather look forward to the treatments.

The amounts of ray given in my cases were as follows:

Time	*Distance*	*Spark gap*	*Ma.*	*Filter*
5 m.	Perineum, 7½ in.	9 in.	5-6	4 mm. Aluminum
	Prostate, 9½ in.			

The difference in the distance used between the perineal and prostate applications is due to the difference in the length of the lead glass speculum used.

This dosage, applied in a series as above described, should not produce an erythema at any time during the course of the treatments—at least it has not done so in any of the cases I have treated.

SUMMARY

1. X-ray treatment of hypertrophy of the prostate is of decided value, and should be given a trial in all the early cases.

2. Many of the cases so treated will not only be temporarily benefited but may escape operation altogether.

3. Cases far advanced, those that have reached catheter life, will be only temporarily and subjectively benefited by the treatment.

4. Prophylactic x-ray treatments, to safeguard against recurrence of symptoms in improved cases, are undoubtedly of value and should be carried out in every case.

ROENTGEN RAY CARDIAC STUDIES

By CHARLES L. MARTIN, E.E., M.D.

DALLAS, TEXAS

THE literature of the past twenty years has contained many excellent contributions covering both the normal and the abnormal roentgen ray appearances of the heart. Dr. Williams[1] of Boston published an article on this subject in 1899, and much was written in German during the early years of the twentieth century. However, the American literature has been devoted more to the discussion of technique and to the study of the normal heart, and it is for this reason that the author is presenting a series of tracings from teleroentgenograms of the chests of patients suffering from actual cardiac conditions. This brief article can in no way compare with the excellent works of such eminent men as Groedel[2] and Vaquez and Bordet[3], but it will perhaps emphasize the practical value of the roentgenogram in the field of cardiology.

TECHNIQUE

Arguments for and against the various techniques tend to carry one far afield, and it has been thought best merely to describe the methods used in studying the cases which are to be presented. These methods are fairly simple and can be executed in a reasonbly short time. They constitute the routine cardiac examination which has been used by the Roentgen Ray Department of the Massachusetts General Hospital for many years and which is fully described by Holmes and Ruggles[4].

The patient first stands facing the observer, with his chest against a fluoroscopic screen of sufficient size to make possible the visualization of all of both lung fields. Tracings are made of the cardiac outlines and the upper and lower limits of excursion of the diaphragm during normal respiration, care being taken to indicate the point of junction of the left auricle with the left ventricle. The patient is then asked to hold his breath in both forced inspiration and forced expiration, while tracings are made of the positions of the domes of the diaphragm and of the left border of the heart. The patient's left hand is next placed upon the top of his head and he is turned to his left until the shadow of the great vessels assumes its narrowest transverse diameter. At this point a tracing of the outline of the great vessels is made and the lower posterior mediastinal space is carefully studied in full inspiration to determine whether or not it is obliterated by the shadows of enlarged auricles or a pericardial effusion. Abnormalities in pulsation are noted on a sheet provided for the purpose. The examination is completed by taking a teleroentgenogram with the anterior portion of the patient's chest held squarely against a cassette. The target of the tube is placed at a distance of seven feet from the cassette and centered on a level with an imaginary line drawn through the scapulae some 2 inches above the lower tips of the angles.

After the roentgenogram is developed, it is marked off with a soft lead pencil as shown in Figure 1, which represents the anatomical divisions of the cardiac shadow. If the shadows of the inner ends of clavicles exactly span the shadows of the bodies of the upper thoracic vertebrae, the plate has been correctly made and is suitable for mensuration. Otherwise it should be discarded, because a slight amount of rotation causes a considerable error in the measurements. The center line is drawn through the center of the shadows of the spinus processes of the vertebrae. "MR" and "ML" represent the distances to the right border and to the left border ordinarily percussed out by the internist. The line "L" is drawn from the point of junction of the right auricle with the right border of the ascending aorta to the apex. Quite often the apex cannot be made out in the roentgenogram. This is par-

ticularly true where the diaphragm is high, as in obesity. In such cases it is necessary to continue the curve of the left ventricle downward and to the approximate position of the apex. "X" is drawn perpendicular to the line "L" from the point of junction of the right auricle and right diaphragm. This point is often not sharply defined, but a slight error in locating it will make very little difference in the length of "X". "Y" is drawn perpendicular to the line "L" from a point on the border of the left auricle appendage. The limits of this appendage cannot be made out on the average roentgenogram of the normal heart, but the length of "Y" will not vary appreciably if the point be selected anywhere along the approximated border of this structure. It is evident that "X" plus "Y" or "B" is the dimension which is increased with enlargement of the auricles, while "L" is more likely to be increased with ventricular enlargement. The dimension marked "Gt. Vs." extends from the right border of the ascending aorta to the left border of the descending aorta, and represents the width of the aortic arch. In some cases the left border of the descending aorta is obliterated by the shadow of the pulmonary artery or left auricular appendage and in such cases the dimension "Gt. Vs." represents the width of the great vessels. It must be remembered that the right border of the shadow of the great vessels is in reality the right border of the ascending aorta, since the superior

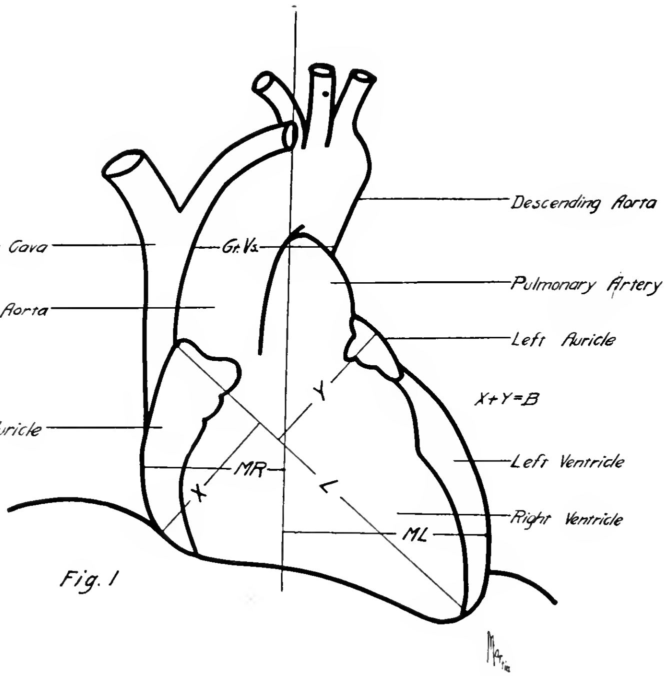


Fig. 1

vena cava casts little or no shadow. In addition to these measurements, it is wise to lay off the internal transverse diameter of the chest.

VALUE OF THE EXAMINATION

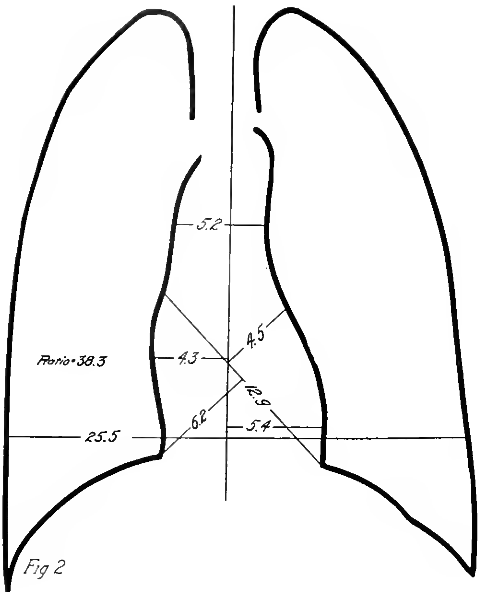
From the examination as outlined above, it is possible to determine the size and shape of the heart and also to determine whether it moves with respiration. The study of pulsations is often disappointing because the excursion of the cardiac borders is so slight that variations are made out with difficulty. According to Groedel, the excursion of the left border of the left ventricle with each heart-beat rarely exceeds two millimeters.

The size and shape of the structure are the most important factors and they can both be determined from the seven-foot plate,

although the fluoroscope brings out variations in shape much better because of distortion. Many good cardiologists now admit that percussion of cardiac outlines is often not a reliable procedure. Danzer[5] has recently called attention to the fact that Thomas Lewis is now using the apex beat in approximating the size of the heart. The same author points out the possible sources of error in such a method and insists on the use of the roentgen ray. Dr. George C. Shattuck[6] demonstrated the inaccuracy of percussion in cardiac work at the Massachusetts General Hospital in 1916, and published an excellent article on the subject at that time. It is now rather generally conceded that the dimensions obtained from the roentgenogram are accurate, but the chief difficulty arises in determining whether the individual heart in question is too large for the patient possessing it. Many tables of normals have been constructed, but they seem to show rather wide variations for each class of individuals listed. In a word, when depending upon tables, it is often necessary to say that the dimensions of a certain heart are at the upper border of normal or, perhaps, a little greater than normal, while the patient seems perfectly well and the roentgenologist hesitates to state definitely that there is real cardiac enlargement present. After applying it to a fairly large series of cases, the author has arrived at the conclusion that the cardiothoracic ratio, as recently advocated by Danzer, gives as much information concerning the size of the heart as do the various tables. Cohn,[7] after examining a series of soldiers, is in full accord with this statement. When using this method, the structure is said to be definitely enlarged when the total transverse diameter, that is, "MR" plus "ML," exceeds one half of the internal diameter of the chest. This ratio is expressed as the quotient obtained by dividing the transverse diameter of the heart by the internal diameter of the chest and can be determined very rapidly without the aid of tables. If only the transverse diameter is needed for this determination, it may seem unnecessary to go further with mensuration, but a study of the following cases will show that the relative values of the measurements "B", "L" and "Gt. Vs." give information of value in certain cardiac disorders. In order to present this work in an orderly fashion, the diseases of the heart will be considered under the headings of the hypoplastic heart, pericarditis, myocarditis, valvular disease, cardio-renal disease, and diseases involving the great vessels. This classification does not include the arythmias or congenital diseases of the heart, because only a very few such cases were studied. All of the congenital cases seen showed cardiac enlargement. All of the drawings, with a few exceptions, were made by tracing the outline of the heart, great vessels, diaphragm and lung fields from the finished teleroentgenograms of actual cases. All the diagnoses, histories and physical examinations except one were taken from the records of the Massachusetts General Hospital.

THE HYPOPLASTIC HEART

The determination of the presence of a hypoplastic or small heart sometimes frees a patient from a restricted cardiac life imposed upon him by some well-meaning physician. Figure 2 represents such a case. The patient had been turned down for the draft because of a definite systolic murmur heard over the precordium. The well-informed clinician now pays little attention to a systolic murmur unless it be accompanied by cardiac enlargement, and when the heart is unusually small, as in this case, the patient may be told with a fair degree of assurance that he has no chronic organic heart disease. It is true that persons who have such small hearts often exhibit the so-called effort syndrome which is so clearly described by Thomas Lewis in his little book bearing that title. Bertnard Smith[8] has recently made a careful study of this subject and finds that the patients that have symptoms for a long time have hearts that are smaller than normal, and that in the teleroentgenograms of such hearts, the angle between the lines "L" and "MR" is greater than the average normal. He also states that the long, narrow



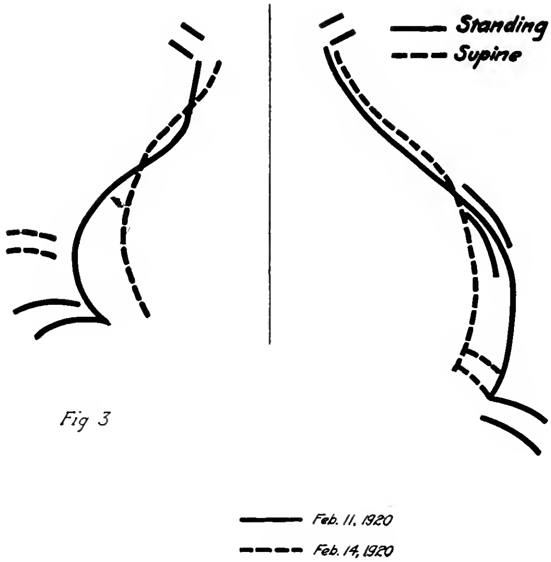


Fig. 2. Hypoplastic Heart. O. P. D. 391673. P. H. Diphtheria, mumps and measles as a child. Has never used alcohol. Tobacco used in moderation. Denies venereal disease. No other important illnesses.

P. I. Has never had any cardiac symptoms but was rejected for the draft because the examining physician found some murmurs.

P. E. Weight 129½ pounds. Age thirty. Apex beat not visible. Impulse forceful and rate rapid as a result of the excitement resulting from examination. No supracardiac dullness. Systolic murmur heard at apex, at second right interspace and in the pulmonic area. Murmur loudest in the aortic area. A_2 sharp and clear; P_2 not accentuated. Second sound at apex clear and pure. Pulses equal and regular and of good volume and tension. Blood pressure 130/80.

Fig. 3. Pericarditis with Effusion. Case No. 24392. May 3, 1916 (morning). P. I. Had an attack three months ago characterized by pain in right side, productive cough, chills, fever, cold sweats, and palpitation brought on by slight exertion. Says she had fluid in chest but was not tapped. Dyspnea has been constant and increasing in severity since this attack. At times everything "looks black." Fainted four days ago. Unable to rest on left side. Cannot sleep. Too sick to answer questions fully.

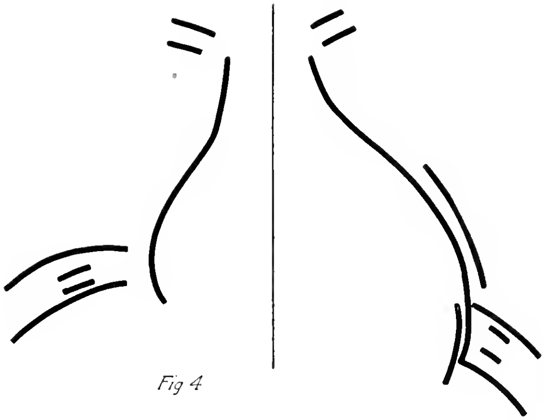
P. E. Apex impulse diffuse and not forceful. Question of shifting with change of position. Sounds regular, rapid, and somewhat muffled. P_2 greater than A_2 and accentuated. "To and fro" friction rub in aortic area and well heard to right of apex. No murmurs made out. Both sounds heard distinctly at apex. A few moist râles and increased whispered voice below right scapula behind.

Operation: A needle was put into the pericardial sac in the 5th interspace 3 cm. to the left of the nipple line and directed upward and inward. After penetrating about 1½ inches through the chest well, 90 c.c. of thick, sticky, yellow fluid were removed. The pulse became fuller and slower and varied from 120–130. The dyspnea and cough subsided and the patient was much more comfortable.

"drop heart" is not predominant type, but that the structure may assume a great variety of shapes. It is well to keep in mind the fact that the small heart is thought to be of definite significance only in the patients that have symptoms, for a great many people possessing such small organs do not seem to suffer any great inconvenience therefrom. The effort syndrome is doubtless the resultant of numerous factors in a poorly developed body, the small heart constituting but one of the many.

PERICARDITIS

The diagnosis of pericarditis with or without effusion has long been one of the most difficult problems confronting the clinician and roentgenologist alike. Dr. George W. Holmes[9] has recently published an excellent account of the findings in the former condition, and through his kindness tracings from one of his cases (Figs. 3 and 4) are presented. According to his observations there is in pericardial effusion a change in the shape of the heart shadow with change in position, an obliteration of the normal curves



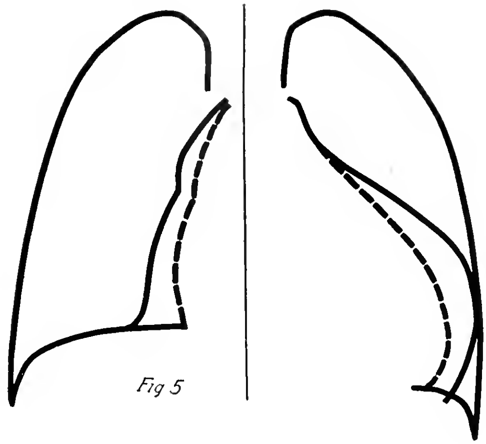


FIG. 4. Pericarditis with Effusion. 26 days after tapping. Question of adhesive pericarditis. Same case as Figure 3. Friction rub still present. Lung signs clearing up. Cardiac dullness much decreased in size. Some anemia. Patient still in bed. Pulse rises when she gets up. Movement of left border of heart seems limited during respiration. Pericardium is probably becoming adherent.

FIG. 5. Acute Dilatation of the Heart. Case No. 235074. Feb. 10, 1920. P. H. Pneumonia as a child. No scarlet fever, tonsillitis, rheumatic fever, or chorea.

P. I. Seven weeks ago she caught a cold and suffered from pain in the chest. After three days she had a cough, chilly sensations, a pain in the side and felt feverish. Was in bed with pneumonia for a month. Got up three weeks ago and has felt pain in right side with a cough ever since.

P. E. Patient is a white girl of thirteen weighing 90 pounds. She has lost seventeen pounds in eight weeks. There are signs of a small amount of fluid at the right base. Heart sounds regular, rapid and of good quality. P_2 greater than A_2 and Sl. accentuated. There is a blowing systolic murmur partly replacing the first sound which is snapping at the apex. Apex shifts in left lateral position. No thrill. Liver dullness extends 5 cm. below the costal margin.

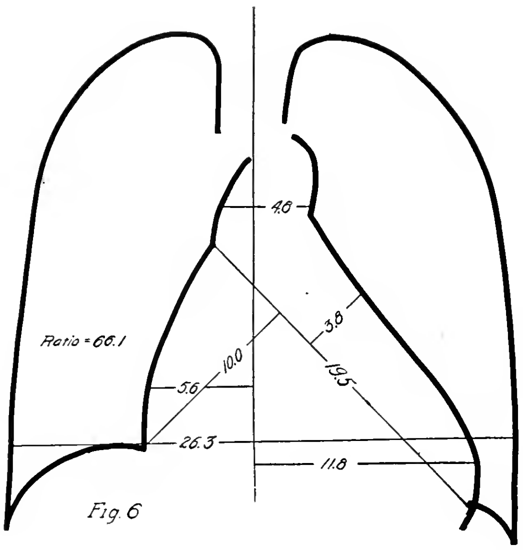
Feb. 15, 1920. Loud friction rub is heard all over the precordia. Loudest just to the right of the sternum in third interspace.

Feb. 24, 1920. Friction rub much diminished.

Feb. 28, 1920. Friction rub no longer heard.

of the cardiac outline and very faint or absent visible pulsation. Fig. 3 represents fluoroscopic tracings made with the patient supine and standing. This case was a long-standing one of tuberculous origin and apparently the pericardium had stretched sufficiently to show considerable change of shape with change of position and had produced the so-called water-bottle appearance. There is some question as to whether an acute effusion of sufficient size to cause tension in the pericardial sac would show this change of shape with change of position. The greatest difficulty in diagnosis arises as a result of the similarity between a pericardial effusion and an acutely dilated heart. They both show a similar shape, faint or absent visible pulsation, and an obliteration of the posterior mediastinal space. The change of shape with change of position does not occur in the case of the dilated heart, and where this change is actually observed a diagnosis of effusion may be made with a fair degree of certainty. Figure 4 represents a fluoroscopic tracing of the cardiac outlines after the disappearance of the effusion shown in Figure 3. The outlines of an acutely dilated heart are shown in Figure 5. The solid line represents the shape which the structure assumed following an attack of pneumonia. The dotted line represents the appearance three days later, when the dilatation had subsided. These drawings were traced from ordinary chest plates made with the same target plate distance. A large effusion would not disappear in three days, and it is because of this fact that the diagnosis was made. It is interesting to note that a friction rub was heard. This is, however, not an unusual finding in acute dilatation of the heart, although it is often interpreted as a sign of pericarditis.

Adhesive pericarditis is no more easily



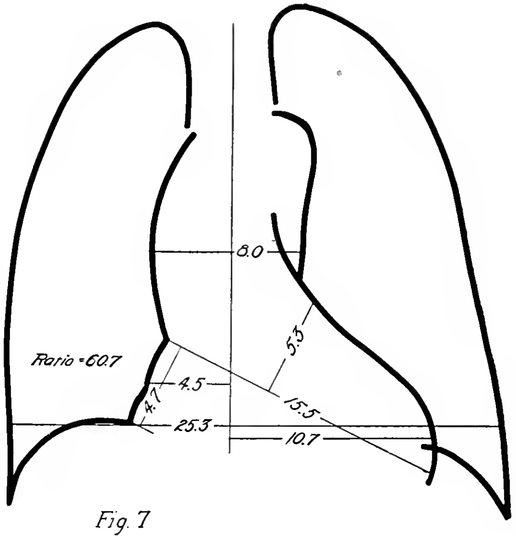


FIG. 6. Double Mitral Disease with Probable Aortic Involvement, Question of Adhesive Pericarditis. Case No. 231847.

P. H. Diphtheria as a child. Rheumatic fever thirteen times since the age of eight. Many bad sore throats. Chorea at age of eight. An attack of dyspnea lasting six weeks occurred six years ago.

P. I. Influenza nine months ago. Attack of rheumatic fever with severe precordial pain and pain in the lower abdomen of a sharp, cramp-like nature six months ago. Constant sharp pain in lower back and right hip began four months ago. Now has a fever, night sweats, and some precordial pain together with sharp pain in the lower abdomen.

P. E. White man. Age thirty-one. Weight 120 pounds. Purpuric rash on ankles. Heavy apex impulse in the fifth space. Sounds regular and of fair quality. Not rapid. P_2 gretaer than A_2. Blowing "to and fro" murmur over the precordia heard best in the third left interspace and transmitted to the axilla, neck and back. First sound slightly roughened at apex. Second sound replaced by murmur. Pulses corrigan in type. Question of thrill at the apex. Blood-pressure 120/40. Brachials negative. Liver edge 2 cm. below costal margin.

Laboratory Findings. R. B. C. 3,000,000. Hbg. 80%. Wassermann positive. Blood cultures show hemolytic streptococcus at four examinations.

Fluoroscopic Report. Practically no respiratory excursion of the left border of the heart.

Fig. 7. Arteriosclerosis. O. P. D. 392975. P. I. Complains of diplopia which began about eight months ago. Growing steadily worse. Also has supra-orbital headaches and "muscular rheumatism." Troubled with nocturia, polyuria and eneuresis.

P. E. White man. Age seventy-two. Weight not obtained. Left eye turned in. Pupils irregular and very small. Fixed to light but react to distance. Palate reflexes absent. Heart sounds regular and of fair quality. Systolic murmur at the apex and slight systolic whiff at the aortic area. A_2 greater than P_2 and accentuated. Blood-pressure 174/112. Left knee swollen and somewhat tender. Slight numbness of both legs. Marked Romberg. Knee jerks absent. Falls when walking around the house. X-ray of left knee shows a narrowed joint space and thickened soft parts. The appearance is that of a chronic synovitis. Clinical diagnosis of tabes was made.

diagnosed than is the type accompanied by effusion. The frequency with which the diagnosis is missed is emphasized by Lyter[10], who describes the findings in thirty autopsied cases. He calls attention to the fact that the left border of the heart should normally move three cm. during deep respiration and should shift three cm. when the patient turns from the right lateral to the left lateral position. The fluoroscopic method of noting the respiratory excursion has already been described. Seven-foot plates made with the patient lying first on one side, and then on the other will demonstrate the lateral shift so that it can be measured. When adhesions occur between the pericardium and the pleura, these two shifts are likely to be diminished or completely done away with. Unfortunately adhesions do not form outside of the pericardium in all cases of pericarditis. When a dense mass of fibrous material forms between the heart and pericardium, the left border often becomes a straight

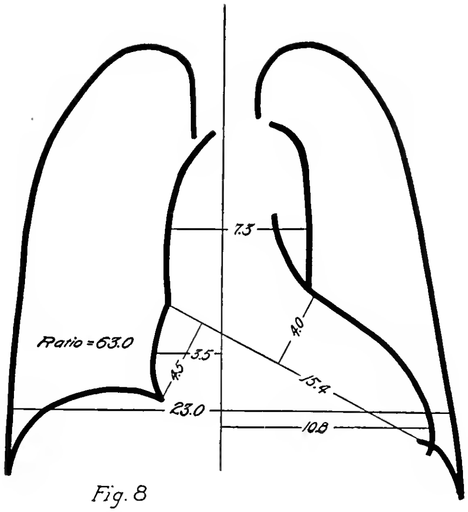


FIG. 8. Senile Heart. O. P. D. 325755. P. H. Negative except for pain in the back beginning one and a half years ago. Never any nocturia. Cta. ceased fourteen years ago.

P. I. Now complains of constant dizziness and hot flashes. Occasional attacks of palpitation. Considerable pain at times over the eyes and in the back. Intermittent edema of the ankles.

P. E. Patient is a white woman of sixty who weighs 190 pounds. Pulse regular. Rate 80. A_2 accentuated. No murmurs. Blood-pressure 220/104.

Laboratory Tests. Wassermann negative. Urine negative.

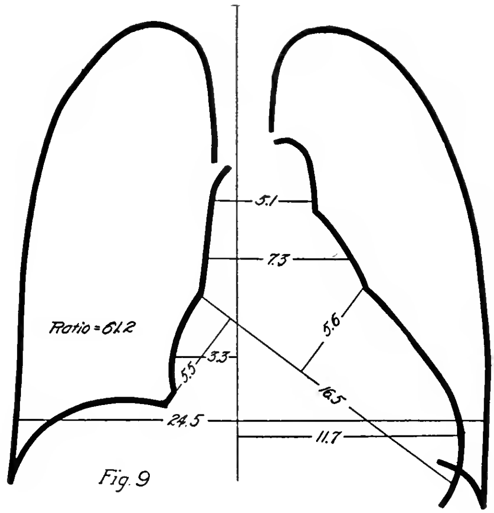


FIG. 9. Hyperthyroidism. W. M. 11454. Nov. 2, 1916. P. H. Scarlet fever at three. Diphtheria at six. Attacks of tonsillitis almost every year.

P. I. Slight swelling of the neck noticed eleven years ago. Tumor reached present size in four months at end of which time patient noticed that her hands trembled. Exopthalmos appeared two years later. Began to notice rapid, powerful heart action, dyspnea on exertion and excessive moisture of palms about one year ago.

P. E. White woman of thirty-six weighing 139 pounds. Appears to have lost weight. Marked exopthalmos and loss of power of convergence. Thyroid very prominent. Right side more so than left. Definite pulsation. Loud bruit heard over gland. Heart enlarged. P_2 accentuated, louder than A_2 and doubled. Loud blowing systolic murmur at apex transmitted to the axilla and upwards. No edema. Coarse and fine tremor of the hands. Blood-pressure 150/84.

Nov. 23, 1916. Right hemithyroidectomy was done.

Metabolism Reports.

Nov. 3, 1916	+17
Nov. 7, 1916	+57
Nov. 14, 1916	+41
Dec. 16, 1916	+39

line and the cardiac shadow assumes the triangular shape which has been described as a sign of adhesive pericarditis. No pulsations or chamber curves are made out, because figuratively speaking the heart is held in a vice of fibrous tissue. Figure 6 represents such a case in which an endocarditis has gone on to a pancarditis with extensive involvement of the pericardium. Needless to say, all of the cases diagnosed clinically as pericarditis do not show definite roentgen ray signs, but these signs when they do occur are perhaps as definite as any elicited in this malady.

MYOCARDITIS

Myocarditis, that is, a disease of the heart muscle, may result from a great variety of causes, but usually produces definite cardiac enlargement in time. This enlargement is often limited to the ventricles and so produces an increase in the long diameter with some prominence of the curve of the left ventricle. The curves representing the left auricular appendage and pulmonary artery are not, as a rule, distinguishable. Cases illustrating two fairly common classes of chronic myocarditis are cited. Figures 7 and 8 are taken from seven-foot plates of patients possessing senile hearts. Perhaps "cardiosclerosis" is a better term than "senile hearts", for these patients are usually rather aged and show definite arteriosclerosis. They may or may not have a hypertension. Definite symptoms are present and some clini-

cians state that the victim has a "dying myocardium" as a result of a poor blood supply to the cardiac muscle. The aortic arch is usually tortuous and wider than normal, and the pulsations of the ventricles often appear to be feeble. Hearts of this type are likely after a time, to become very long and narrow, and resemble a beef tongue in appearance, the apex corresponding to the tip of the tongue. No evidence of the left auricular appendage can be made out and the whole organ appears to assume a horizontal position in the chest. No roentgenologist is justified in diagnosing this condition from the roentgen ray findings alone, but when such an appearance is encountered in a person past middle age, who shows arteriosclerosis and is complaining of vertigo, dyspnea, palpitation, and perhaps angina, the diagnosis cannot be far wrong. It is a rather interesting fact that the patient whose heart is shown in Figure 7 was said to have tabes. A number of tabetics were examined and almost without exception they showed hearts of this type. They were examined with the hope that they would show definite signs of syphilitic aortitis. It has often been stated that syphilis is an etiological factor in arteriosclerosis and these findings would seem to substantiate this statement because some of the patients examined had not reached the age of forty.

Chronic hyperthyroidism is usually accompanied by a myocarditis which produces definite cardiac enlargement. Such a case is illustrated in Figure 9. Cardiac enlargement was found by the author only in patients who had had symptoms of hyperthyroidism for a number of years. The prominent curve of the left ventricle and the increased length are well shown in the case cited. Many cases show the prominence in the region of the pulmonary artery as shown here. This may possibly represent the border of an enlarged thymus gland. Such an enlarged gland was demonstrated in one such case at autopsy. When the heart has once become affected in these cases, it is in no way benefited by a reduction of the thyroid secretion except in so far as a reduction of the pulse rate may serve to reduce the load carried, and patients may continue to have dyspnea on exertion and some tachycardia after the basal metabolism is reduced to normal, as a result of a myocarditis. The roentgenologist is fairly safe in making this diagnosis in old cases of hyperthyroidism that show definite ventricular enlargement.

VALVULAR DISEASES

A case of acute endocarditis is rarely sent to the roentgen ray laboratory because absolute rest in bed is one of the essentials of treatment and the heart is not so likely to show a characteristic shape during the febrile stage of the disease. However, when the infection subsides and the valve cusps are retracted or stenosed as a result of the formation of scar tissue, the valves begin to leak. This increases the cardiac load and the various chambers become dilated or hypertrophy in an effort to take care of the added work. It is at this stage that the roentgen ray examination should be attempted.

Generally speaking, the valves of the heart are open to two lines of attack. Syphilis beginning in the aorta is likely to move downward and involve the aortic valve, but extends no further along the endocardium. Rheumatic infections, on the other hand, usually begin at the mitral valve and may extend upward to the aortic valve but do not involve the aorta. Other valves may at times be affected, but such lesions are rarely correctly diagnosed before death. An occasional case of rheumatic involvement of the aortic valve alone is encountered now and then.

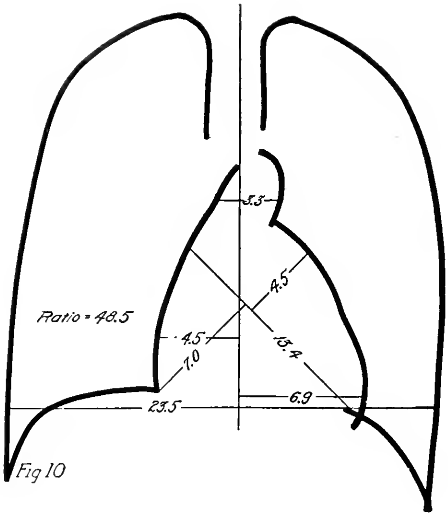
When the mitral valve fails it may show stenosis or a combination of stenosis and insufficiency. Autopsy findings at the Massachusetts General Hospital seem to indicate that pure insufficiency is a rather rare lesion of the mitral valve. No matter what the lesion may be, a failure of the efficiency of the valve disturbs the mechanical balance of

the heart, and blood is either held back or is allowed to regurgitate back into the left auricle. This causes dilatation of that structure and a prominent of the left auricular appendage curve in the roentgenogram. Pulmonary congestion results, and an extra load is thereby thrown upon the right ventricle which in turn passes it back to the right auricle. With an incompetent valve much blood from the dilated left auricle flows into the left ventricle during diastole and causes some increase in the size of that structure. Since the right ventricle pumps blood into the lungs through the pulmonary artery it is also likely to show some dilatation and this helps to accentuate the prominence of the curve of the left auricular appendage, since the shadows of the two structures adjoin one another. The extra load on the right auricle usually causes a marked prominence of the right border of the heart. The enlargement of the right ventricle causes an increase in both the transverse diameter and the distance across the auricles. From this brief description it is evident that the changes produced tend to increase the dimension "B" (equals "X" plus "Y"). When the mitral valve is incompetent "L" may also show some increase as a result of a certain amount of enlargement of the left ventricle; but this is, as a rule, not a striking change.

In examining cases of chronic mitral disease fluoroscopically, it is not at all uncommon to find the lower posterior mediastinal space entirely obliterated by enlarged auricles which extend backward until they come in actual contact with the spinal column. Figure 10 illustrates the findings in a case diagnosed clinically as pure mitral stenosis, whereas Figures 11 and 12 represent double mitral disease. It is interesting to note that in Figure 10 the transverse diameter of the heart does not definitely exceed 50 per cent of the internal diameter of the chest, although the heart has a typical "mitral shape." This is, no doubt, due to the absence of enlargement of the left ventricle. Groedel calls attention to the fact that the cardiac shadow may be relatively small in mitral stenosis, and this is probably the only type of chronic organic heart disease in which the cardiothoracic ratio does not always indicate enlargement. Figure 11 shows a marked prominence of the curve of the right auricle. Figure 12 shows this same prominence combined with an enlargement of the left auricle sufficiently great to obliterate completely the angle normally seen between the descending aorta and the remainder of the left border of the heart. These three drawings illustrate the fact that in mitral disease the dimension "B" approaches the dimension "L" as a limit and as a result the cardiac shadow tends to assume a circular shape. No other cardiac disturbance produces the same series of changes, and when the roentgenologist observes such configuration he is justified in suggesting the diagnosis of mitral disease which should, of course, be checked up by a physical examination.

If the rheumatic infection extends to the aortic valve and a double valve lesion results, the left ventricle of necessity takes up a larger share of the increased load and becomes definitely enlarged. The apex may as a result descend to the level of the sixth interspace in front and on the long diameter is definitely increased. It is only necessary to add to the mitral picture an increased length and a prominence of the curve of the left ventricle to produce the appearance of double valvular disease, as illustrated in Figures 13 and 14. The curve of the left ventricle becomes relatively more and more prominent as we pass from mitral stenosis through double mitral disease to aortic regurgitation.

Pure aortic stenosis is an extremely rare condition and is diagnosed by good clinicians only after much deliberation. The case illustrated in Figure 15 was so diagnosed. It is quite possible that myocarditis is responsible for some of the changes seen. Two points of interest may be noted. The enlargement is limited to the ventricles, chiefly the left, since the distance "B" extending across the right ventricle is not increased, and the aortic



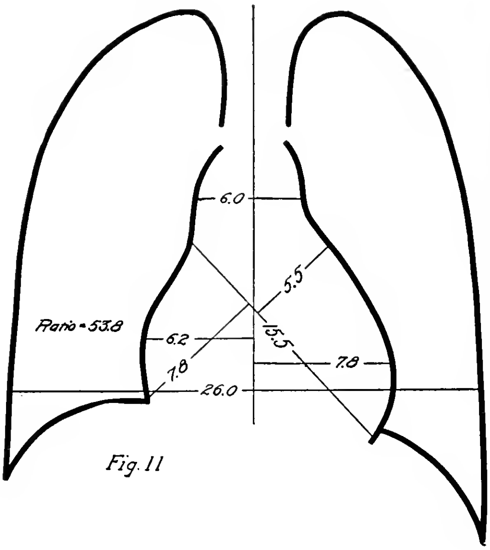


Fig. 10. Mitral Stenosis. Case No. 231751. P. H. No history of children's diseases. For several years has been troubled with attacks of dyspnea, cyanosis, and a choking sensation after exertion. No productive cough or edema. Some attacks accompanied by knife-like precordial pain and a dry cough.

P. I. Balance of past year spent in bed. Attacks characterized by dyspnea, dry cough, cyanosis, palpitation, and sharp precordial pain still occur.

P. E. White girl. Weight, 117 pounds. Sounds regular, and rapid. P_2 greater than A_2 and accentuated. Pre-systolic roll at apex. First sound loud and sharp. Slight systolic and loud rough diastolic murmur at apex transmitted to axilla. Slight thrill in fifth interspace. Blood-pressure 110/65.

Laboratory Findings. Renal function 50 per cent. Wassermann negative.

Fig. 11. Mitral Disease (probably double). Case No. 232110. P. H. In bed with rheumatic fever one month, four years ago. Scarlet fever followed by rheumatic pain which kept him in bed ten weeks, seven months ago. Venereal denied. No tobacco or alcohol.

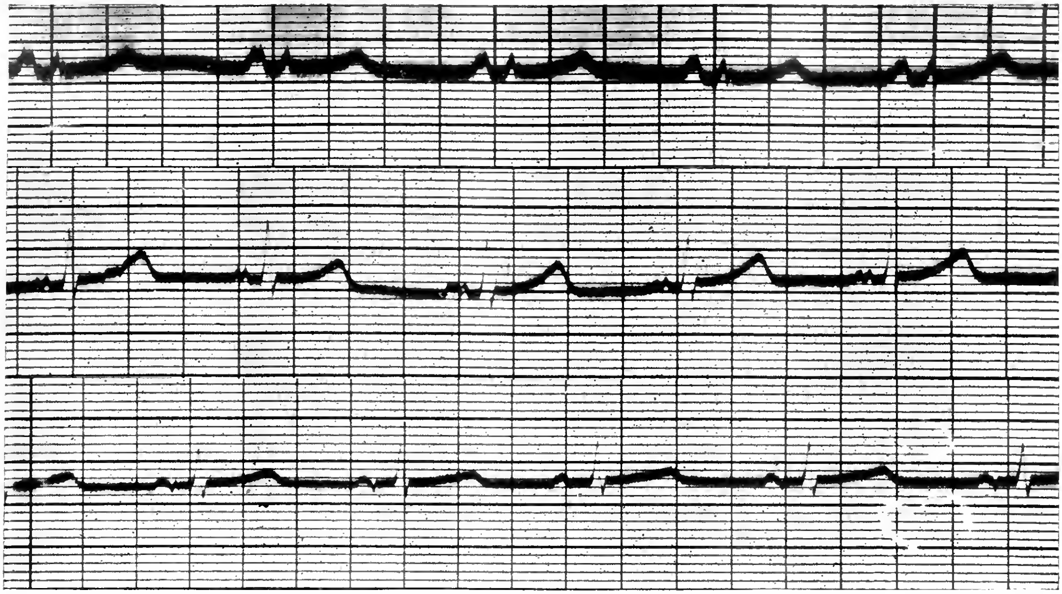
P. I. Turned down by draft board about one year ago. Dyspnea and palpitation followed attack of scarlet fever and rheumatism seven months ago. No edema. Chief complaint at present is dyspnea, weakness and palpitation following exertion.

P. E. White man. Age twenty-one. Weight 138. Mucous membrane cyanotic. Tonsils red, large and ragged. Venous pulsations seen in neck. Cervical glands palpable. Heart impulse heaving and diffuse, and seen in 4th interspace. Sounds regular and slightly rapid. First sound replaced by systolic murmur, transmitted to axilla, precordia and back. No definite thrill. P_2 greater than A_2. Reduplicated and accentuated. Arterial walls not palpable. Brachials not tortuous. Blood-pressure 140/70. Knee jerks present and equal.

Laboratory Findings: Urine negative. Wassermann negative.

arch is normal in size and shape. The normal arch makes the presence of syphilitic aortitis, cardio-renal disease with hypertension, or arch sclerosis rather unlikely, and it is therefore necessary to explain the ventricular enlargement as resulting from a rheumatic infection of the aortic valve, a myocarditis, or an aortic stenosis. It is very unlikely that any roentgenologist would be so rash as to hazard the correct diagnosis on the basis of the roentgen appearance alone.

Aortic valve involvement is in a large majority of adult cases due to syphilis and its onset is likely to be preceded by a syphilitic aortitis of the ascending aorta. Figure 16 illustrates an advanced case of this type. There is a marked increase in the width of the aortic arch and a prominence in the lower part of the ascending portion which probably represents a localized dilatation. The heart is very long and lies transversely in the chest as a result of a high diaphragm. The auricles are not enlarged, but the curve of the left ventricle is very prominent. The distance across the base "B" is not outside normal limits, and it may be inferred that the left ventricle is enlarged much more than the right. Left ventricular preponderance is often present in cases of aortic regurgitation.



Graph. I. Illustrating Figure 10. Broad notched "P" wave of the type often seen in mitral stenosis.

CARDIO-RENAL DISEASE

A patient with damaged kidneys who has maintained a high blood-pressure for a long time must of necessity possess a large hypertrophied heart if he is to keep his bodily machine operating. If the hypertrophy is not sufficient to meet the heavy demands of a high blood-pressure, he suffers from various cardiac symptoms. The hypertrophy is usually pretty well distributed between the two ventricles, and as a result such hearts become enormous in size. Figures 17 and 18 show fairly typical cases. The aortic knobs are prominent, perhaps as a result of arteriosclerosis, which is often present in cardiorenal disease. Although the curves representing the auricles are not at all prominent, the distance "B" is outside normal limits and this seems to indicate the presence of a definite hypertrophy of the right ventricle. The increased length of the heart and the prominence of the curve of the left ventricle point toward hypertrophy of that structure. The roentgenologist is not always justified in describing an increase in cardiac size as due to hypertrophy rather than dilatation, but in these cases the vigorous pulsations observed fluoroscopically seem to point in that direction. Early cardio-renal cases do not show such pronounced changes and may be easily confused with other conditions causing ventricular enlargement.

DISEASES INVOLVING THE GREAT VESSELS

This subject was more fully covered in a previous article[11], but this survey of diseases of the heart would hardly be complete without some reference to it. Many of the drawings shown here were used in the previous article. It is probably true that a large number of cardiac cases are sent to the roentgenologist because the clinician is afraid that he may be overlooking a syphilitic aortitis or to check up his diagnosis of that condition. The diagnosis of aortitis should be made with the greatest caution in cases showing widened shadows of the great vessels. Arteriosclerosis, hypertension, chronic mitral disease, a high diaphragm, or an enlarged pulmonary artery may produce widened shadows of the great vessels.

Figure 19 illustrates a typical wide, tortuous aortic arch of the type seen in advanced arteriosclerosis. The widening is apparently due to the fact that the descending aorta swings to the left. The aortic knob

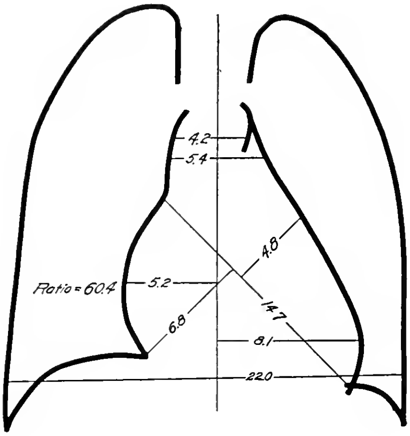


Fig. 12

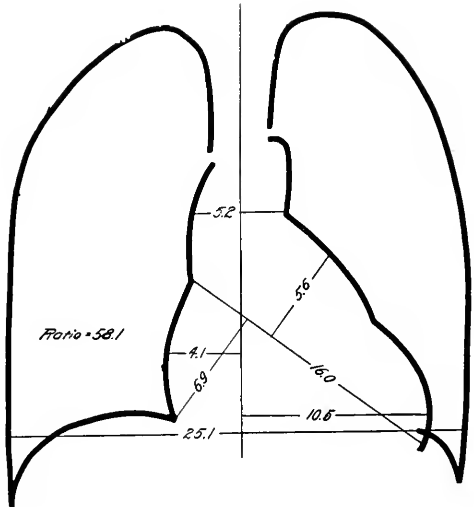


Fig. 13

FIG. 12. Mitral Disease and Chorea. O. P. D. 244944. June 13, 1914. P. H. Negative except for scarlet fever five months previously.

P. I. Has complained of tenderness on being touched for several weeks. Is very nervous and rather weak.

P. E. Patient is a white girl seven years of age. Tonsils are ragged and protrude. Heart is swollen. Heart is not enlarged. Sounds regular and of good quality. No murmurs heard. No swollen or tender joints. Considerable choreiform movement.

Mar. 20, 1920. P. E. Heaving apex impulse in the 5th space 10 cm. to the left of the midsternum. Loud systolic murmur at the apex partly masking the 1st sound. Pulmonic 2nd sound very loud and reduplicated at the apex. Slight diastolic rumble when the patient lies down.

FIG. 13. Double Mitral Disease and Aortic Regurgitation. O. P. D. 392730. P. H. Has had attacks of rheumatic fever and sore throats during the past year. No other serious illnesses.

P. I. Comes in complaining of pain in all of the joints of the body which has been worse during the past three months. Dyspneic after climbing a flight of stairs. Occasional edema of the ankles.

P. E. The patient is a white man of twenty-four who weighs 140 pounds. Heart sounds regular. There is a loud blowing systolic murmur heard all over the precordia with a maximum intensity at the apex. The murmur is transmitted to the axilla. P_2 is accentuated. There is an early diastolic murmur heard just to the left of the sternum in the 3rd interspace. The apex is felt in the 6th space. The apex impulse is felt in the 6th space.

Laboratory Tests. Wassermann negative.

is usually prominent in arch sclerosis even though it be partially obliterated by the shadow of the descending portion of the vessel. If the patient be rotated to the left in the fluoroscope until the shadow of the ascending aorta overlies that of the descending aorta, the transverse dimension of the resultant shadow should not seem too large. It is often possible to take plates in the left oblique position which show the entire ascending, transverse, and descending thoracic aorta. The heart illustrated in Figure 19 might be said to be a sequela of cardio-renal disease, but the nephritis is probably arteriosclerotic in origin, and the sclerosis of the arch may have preceded the nephritis.

Arteriorsclerosis is to be expected in the aged; but younger people sometimes have it. A case of arteriosclerosis with hypertension and a wide, tortuous, aortic arch is shown in a woman of thirty-nine in Figure 20. A girl in the early twenties with a similar condition was also observed. These cases of precocious arteriosclerosis are not so uncommon as one might suspect, and it is just such a case that is most likely to be branded as syphilitic when a wide arch is discovered.

The obese patient almost always shows a wide area of supracardiac dullness, and in many cases this is due to the high position of the diaphragm. Figure 21 shows three wide arches observed in obese persons and also the widening of the arch resulting from forced expiration in an individual of average size. The position of the diaphragm should be carefully observed in aortitis suspects.

The effect of chronic mitral disease on

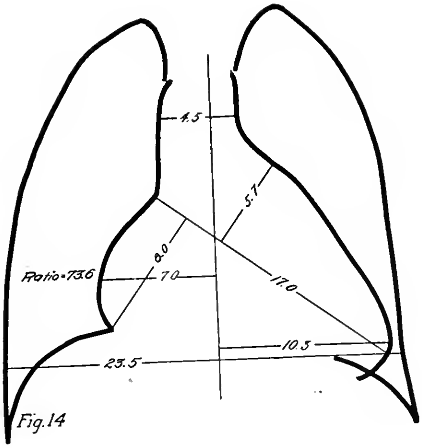


Fig. 14

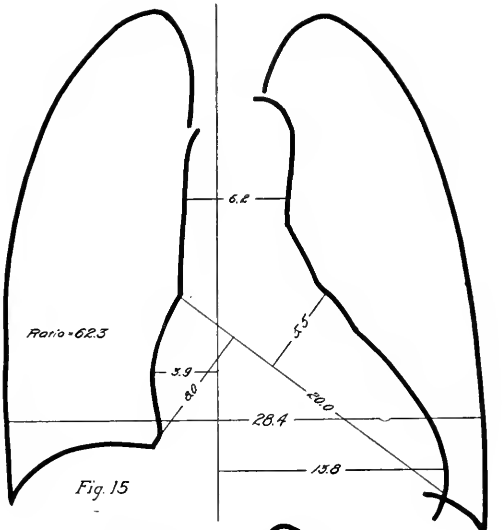


Fig. 15

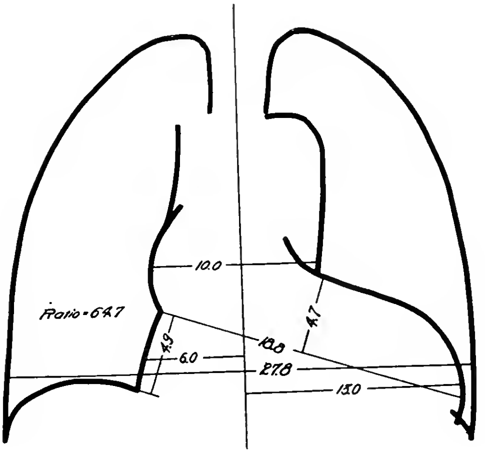


Fig. 16

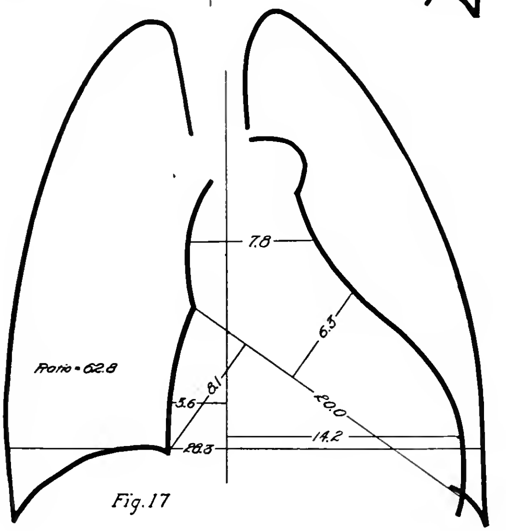


Fig. 17

Fig. 14. Double Mitral Disease and Aortic Regurgitation. P. H. In bed with polyarticular rheumatism eleven years ago. Similar attacks since. Influenza and pneumonia nine months ago.

P. I. Pain appeared in precordia and right shoulder two years ago. Became dyspneic on exertion eleven months ago after an attack of influenza. A severe rheumatic attack occurred one month ago.

P. E. Apex impulse in 5th space. Sounds of good quality. Occasional premature beat. P_2 greater than A_2 and much accentuated. Loud blowing systolic and diastolic at the apex. "To and fro" murmur at the base. Arterial walls palpable. Thrill at the apex. Blood-pressure 126/60. Wassermann negative. Age, twenty-six. Weight 104 pounds.

Fig. 15. Aortic Stenosis. Case No. 230864. P. H. A painter for thirty years. Lead colic sixteen years ago. Gonorrhea at twenty. Syphilis denied. Much alcohol up until ten years ago.

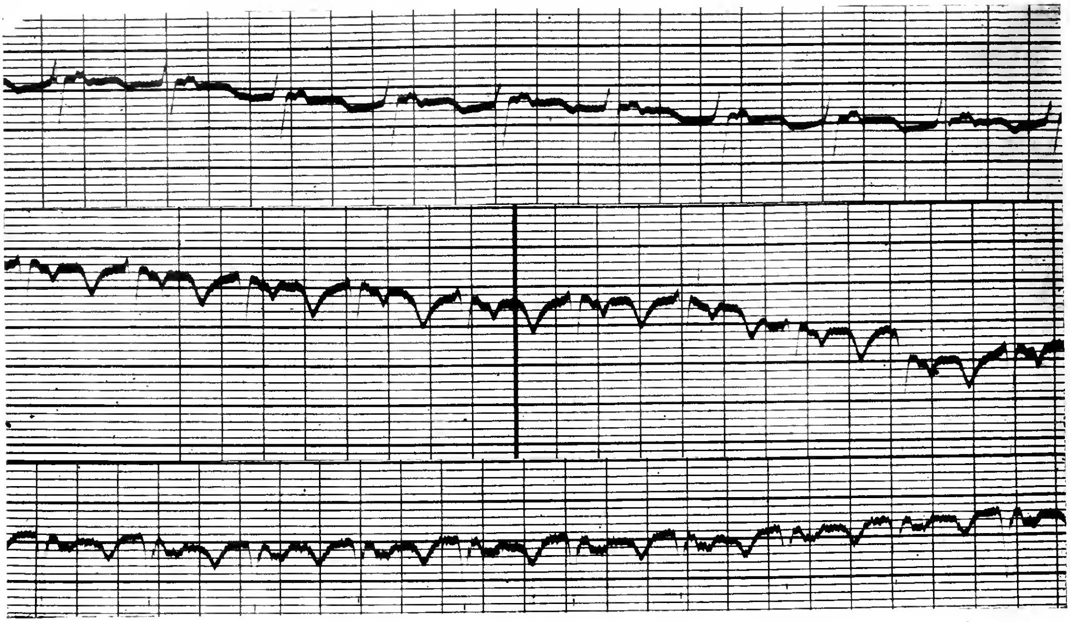
P. I. Three years' duration beginning with dyspnea and palpitation. Aching pains in legs began eighteen months ago, worse in evening. Cough began five months ago. Edema of ankles for past three weeks with cyanosis and dyspnea on exertion.

P. E. Age fifty-eight. Weight 144 pounds. Brachials sclerosed. Harsh blowing systolic murmur at base, heard best in aortic area and transmitted to neck. Double murmur at apex which disappeared after rest in bed. Systolic thrill in aortic area. Blood-pressure 115/90. Wassermann negative. Electrocardiogram shows left ventricular preponderance and premature ventricular contractions.

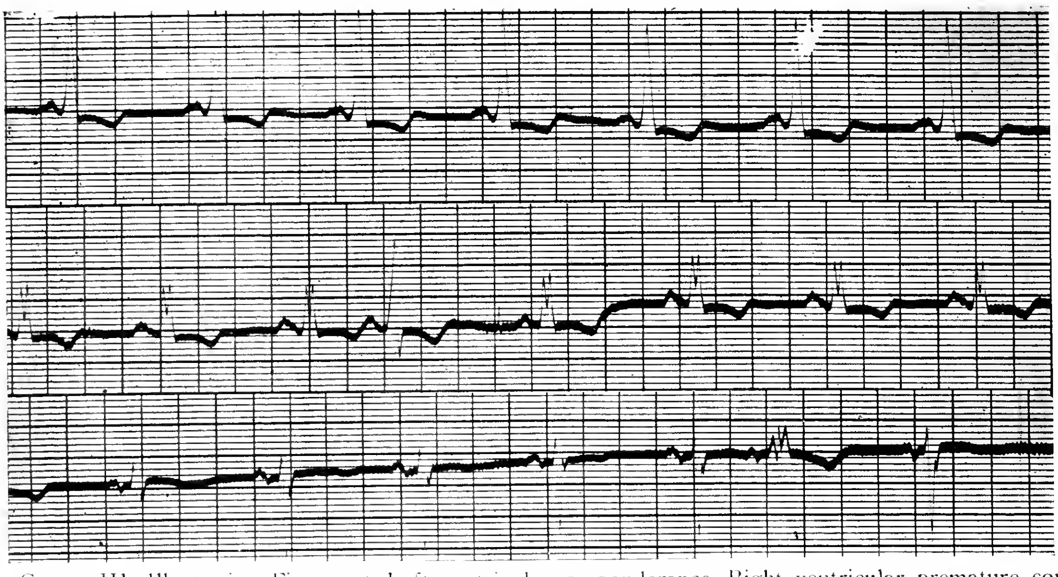
Fig. 16. Syphilitic Aortitis and Aortic Regurgitation. O. P. D. 404570. P. H. Has had pneumonia twice. Gonorrhea twenty-five years ago. Married thirty years. Wife has never been pregnant.

P. I. Has suffered from epigastric distress, dyspnea, and palpitation on exertion for about eight months. No edema.

P. E. Negro man. Age sixty-one. Weight 185 pounds. Blood-pressure 200/80. Knee jerks absent. Pupils sluggish. Brachial arteries sclerosed and tortuous. Corrigan pulse. Double murmur in the aortic area. Diastolic murmur to the left of the



Graph II. Illustrating Figure 14. Tachycardia. Broad notched "P" waves in all leads.



Graph III. Illustrating Figure 15. Left ventricular preponderance. Right ventricular premature contractions. Aberrant ventricular contractions. Invert "T" wave. "P" wave broad and notched in leads I and II.

sternum. A_2 absent. Pistol shot sound in the groin. Visible pulsations in the neck.

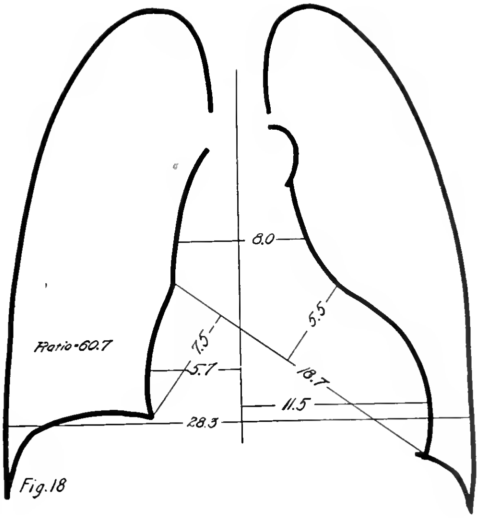
Laboratory Findings. Urine not definitely abnormal at one examination.

Fig. 17. Cardio-Renal Disease. Case No. 231934. P. H. Diphtheria at twenty-five. Tonsillitis at same time. Syphilis at age of twenty. Does not drink steadily but goes on alcoholic sprees.

P. I. Nocturia began one year ago; has gotten progressively worse. Severe frontal morning headaches began seven months ago. Attacks of dyspnea during past seven months. Blurring of vision and spots before the eyes for past three months. Dizzy vomiting spells for past two months. Cramps in legs recently.

P. E. White man. Age forty-nine. Weight 150 pounds. Sounds regular and rapid. P_2 greater than A_2. Both accentuated. Soft systolic murmur over precordia heard best in the 4th left interspace. Pulses equal and of high tension. Arterial walls palpable. Blood-pressure 210/140. Brachials tortuous. Fundi show albuminuric retinitis.

Laboratory Findings. Renal function 10 per cent. Wassermann negative.



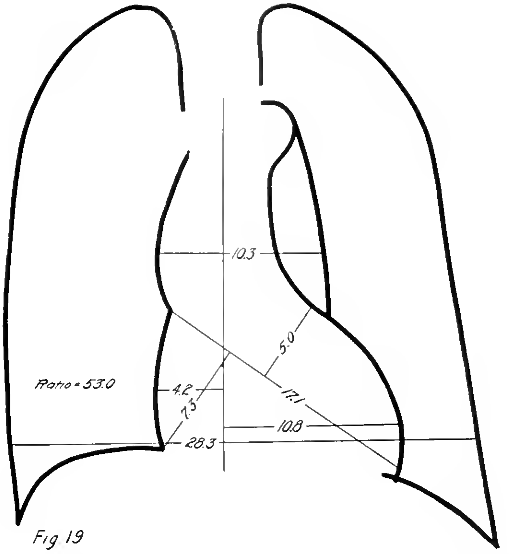


Fig. 18. Cardio-Renal Disease. Case No. 233130. P. H. No diseases except scarlet fever in childhood. Always a heavy meat-eater. Used much alcohol up until two years ago. A heavy smoker.

P. I. Began to complain of dyspnea and a "lazy" feeling about three years ago. Has been in the hospital twice before because of worn out feeling. Orthopnea became noticeable two weeks ago and was accompanied by nocturia and edema of the ankles, lower legs, and thighs. No precordial pain at any time.

P. E. White man fifty-two years old, weighing 196 pounds. Jan., 1917. Sounds regular and of good quality. Rate normal. Soft systolic at the apex. Second sounds accentuated. Liver edge felt 2 cm. below the costal margin. Electrocardiogram showed left ventricular preponderance. Wassermann negative. Renal function 30 per cent. Urine showed a Sp. Gr. of 1020-24, albumin V. S. T. to S. T., and many hyaline casts. Blood-pressure 180/110.

May, 1919. P_2 equals A_2. Shrill high pitched murmur in the mitral area. No thrill. Brachials tortuous. Blood-pressure 210/140 to 230/140. Renal function 20 per cent to 25 per cent. Urine showed hyaline and granular casts and a Sp. Gr. of 1012 to 1020.

Oct., 1919. Second sounds accentuated. Blowing musical systolic murmur at the apex transmitted to the axilla. Radial arteries sclerotic and beaded. Blood-pressure 220/150. Râles in bases of lungs. Edema of angles and thighs. Fundi showed sclerosed and tortuous arteries and small sclerotic plaques. Urine shows a Sp. Gr. of 1010-14, a T. to V. S. T. of albumin and hyaline and granular casts. R. F. 25 per cent. Hbg. 70 per cent.

Fig. 19. Arteriosclerosis with Nephritis. Case No. 232022. P. H. Scarlet fever in childhood. Sick several months twenty years ago with nausea, diarrhea, vomiting and abdominal pain. "Grippe" four years ago. Generalized edema with headache, blurring of vision and delirium three years ago. A "shock" occurred one year ago. Unconscious for twenty-four hours. Some weakness in left arm and leg since. Venereal denied.

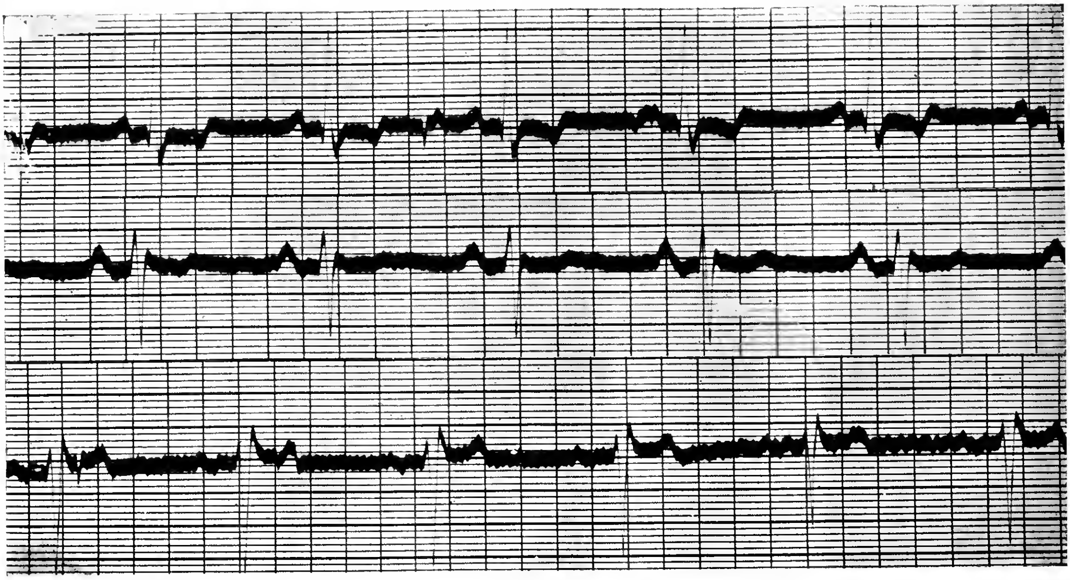
P. I. Feels weak and tired. Still has weakness of left arm and leg. Has attacks of dizzy sensations accompanied by vomiting, a feeling pressure in the head, and a general numb feeling.

P. E. White man. Age sixty-four. Weight 175 pounds. Pupils irregular. Cardiac impulse seen and felt in the 6th space. No thrills. Sounds regular and of fair quality but rapid. A_2 greater than P_2 and accentuated. No murmurs. Arterial walls palpable, brachials not tortuous. Blood-pressure 208/120. Knee jerks normal.

Laboratory Findings. Urine shows a trace of albumin, a Sp. Gr. of 1020 to 1023 and a frequent hyaline and granular cast at two examinations. R. F. 12 per cent. Wassermann negative.

the contour of the left border of the cardiac shadow has been discussed under the subject of "Valvular Disease." In Figure 12, the supracardiac dullness is shown definitely increased as a result of dilatation of the pulmonary artery and left auricular appendage. The clinician is very familiar with the increase in percussion dullness to the left of the sternum with the enlargement of the left auricle. Such cases present a fairly typical cardiac shadow and are not likely to be confused with aortitis.

The increased width of the supracardiac shadow accompanying chronic hypertension is well brought out in Figures 17 and 18. Smith and Kilgore[12] have called attention to a series of such arches in cases of cardio-



Graph IV. Illustrating Figure 18.

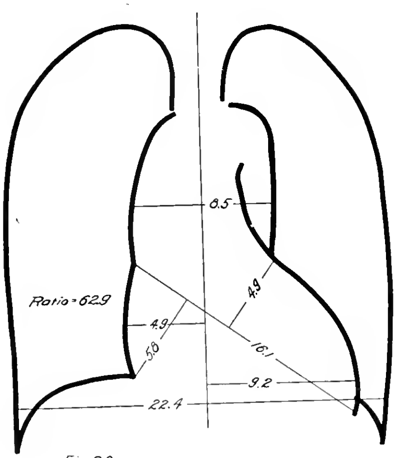


Fig 20

Fig. 20. Precocious Arteriosclerosis with Hypertension. Case No. 233568. P. H. No rheumatic history. No miscarriages. Venereal denied. "Tubes and ovaries" removed eleven years ago for pelvic abscess.

P. I. Weak and tired and subject to "hot flashes" and "cold sweats" since the age of eighteen. Dyspnea began three years ago. About two years ago she began to have palpitation and severe headaches accompanied at times by vomiting, dizziness, staggering, stars before the eyes and on two occasions everything turned black before her eyes. During the past year the above symptoms have been less but there has been some edema of the ankles and a numb feeling in the right leg and arm at intervals. No nocturia or other urinary symptoms.

P. E. Patient is a pale white woman, age thirty-nine, weighing 112 pounds. Marked venous pulsation in neck. Sounds regular and rapid and of good quality. A_2 is greater than P_2 and much accentuated. Reduplicated 1st sound and a systolic murmur at the apex transmitted to the axilla. Systolic murmur in the aortic area not transmitted. Very questionable thrills observed at the apex and at the aortic area. No presystolic murmur. Arterial walls palpable. Brachials tortuous. Blood-pressure was 270/190 six months ago and is 210/140 now.

Laboratory Findings. Urine shows nothing abnormal except S. P. T. of albumin and a rare white cell at numerous examinations. No fixation of gravity or retention of chlorides. Renal function 60 per cent. Non-protein nitrogen 35.9 mgs. per 100 c.c. of blood. Wassermann negative twice.

renal disease with hypertension, in which no evidence of syphilitic infection could be found. It has been claimed that the widening is due to a dilatation of the aorta resulting from the long continued high blood pressure. Some think that arteriosclerosis is also a factor. No matter what the etiology may be, it is a proven fact that the transverse dimension of the great vessels in such cases may measure 7, 8, or even 9 cm.

A dilatation of the pulmonary artery is only met with occasionally, but when it occurs, the appearance is very typical and produces a definite widening of the shadow of the great vessels resulting from a sharply defined prominence in the region of the pul-

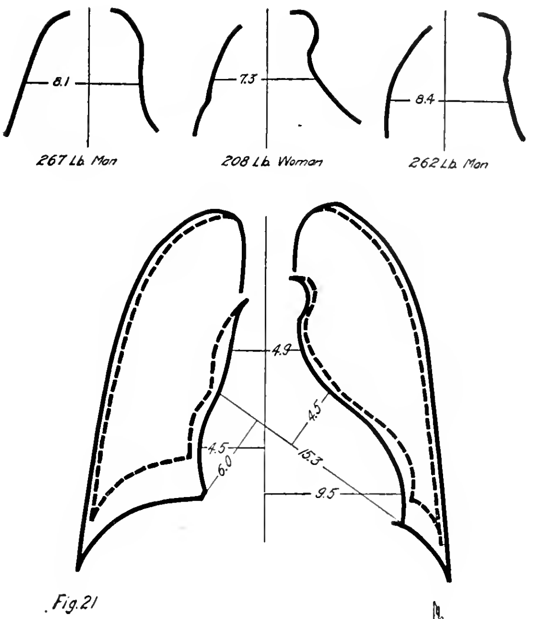


FIG. 21. Widening of the Shadow of the Great Vessels Due to a High Diaphragm. The three upper tracings represent the size and shape of the great vessels in patients weighing over 200 pounds. In each case there was a high diaphragm probably due to a large amount of abdominal fat. These sketches are traced from the seven-foot plates. In well built individuals weighing over 200 pounds and possessing a normally placed diaphragm the great vessels rarely measure over 6 cm. in width.

The large drawing represents the shape and size of the heart, great vessels, and thoracic cavity of a well built man thirty-nine years of age and weighing 142 pounds. The solid outline was made from a seven-foot plate taken during normal breathing while the broken outline was traced from a seven-foot plate of the same patient during forced expiration. This man was a recently discharged soldier who had been leading an active life and he had a good diaphragmatic excursion. During expiration the diaphragm rises and the chest walls are drawn in. The heart is forced upwards but apparently the upper portion of the aortic arch remains fixed. As a result the heart and great vessels are compressed and a widening of their transverse diameters results.

This patient came in complaining of a feeling of fullness in the chest which was worse after meals and had been present for about a year. There were no other symptoms. On auscultation there was a double murmur in both the aortic and mitral areas and A_2 was sharp. The pulse pressure was a little higher than normal. There was no rheumatic or syphilitic history. The electrocardiograph showed nothing abnormal. He was thought to have an early involvement of both the aortic and the mitral valves of rheumatic origin.

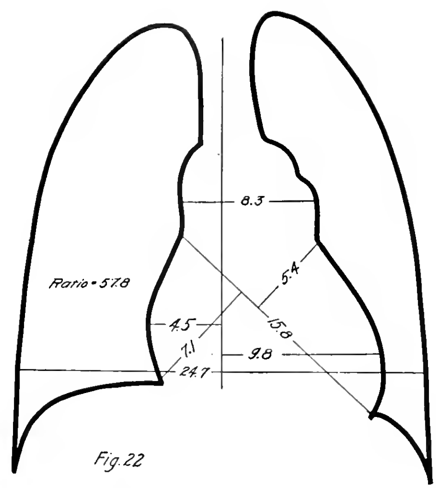


FIG. 22. Dilated Pulmonary Artery. Case No. 145038. P. H. Croupous pneumonia at twelve. Typhoid and diphtheria at thirteen. Question of bronchopneumonia at twenty-five. No rheumatic history. Question of chancroid eight months ago. In the hospital with a "cold" for two weeks about four months ago. Has been working but never "up to snuff." Some precordial pain and dyspnea for past two years.

P. I. Has complained for the past four days of headaches, "hot and cold" sensations, pains all over the body, and a cough accompanied by pain in the left lower chest. This condition was diagnosed as a mild bronchopneumonia.

P. E. White boy twenty-six years old weighing 124 pounds. At the age of twelve: Heart outside the nipple line three and one half inches from the mid-sternum. No increase to the right. Action rapid and regular. Second sound at apex accentuated. P_2 equals A_2. Systolic murmur at the apex not transmitted. In the hospital with croupous pneumonia at this time.

At the age of thirteen: Heart in the 5th space in the anterior axillary line. No increase to the right. Action rapid and regular. P_2 very much accentuated and equals A_2. First sound replaced by a systolic murmur heard all over the precordia, loudest in the mitral area and transmitted to the axilla. Spleen palpable. In the hospital at this time with diphtheria and typhoid.

At the age of twenty-five: Heart apex impulse felt and seen 12 cm. to the left of the mid-sternum line. Sounds regular and of poor quality. P_2 is accenuated and reduplicated and equals A_2. Short systolic murmur at the apex transmitted to the axilla. Short diastolic just to the left of the sternum. Blood-pressure 110/60. X-ray showed a prominence of the pulmonary artery and a thickening of the hilus shadows and lung markings. Diagnosis, mitral insufficiency and question of broncopneumonia at this time.

At present: Impulse heaving. Sharp slap felt half way between the pulmonary area and the apex. P_2 greater than A_2 and much accentuated. Soft systolic murmur at the apex. Second sound loudest where slap is felt, and synchronous with it. No thrill. Blood-pressure 148/110. Sputum shows Type IV pneumococcus and blood culture shows staph. albus.

Graph V. Illustrating Figure 22. Marked right ventricular preponderance, a condition found most commonly in mitral stenosis, congenital heart, and chronic pulmonary disease of a type causing pulmonary artery dilatation.

monary artery. Such a picture may be obtained with a patent ductus arteriosus, a pulmonary stenosis, or an aneurysm of the pulmonary artery. It is conceivable that some form of obstruction to the pulmonary circulation might cause it. A patent ductus arteriosus is probably the most common cause. Figures 22 and 23 show rather typical cases. Hubeny[13] has written an excellent description of this condition. The appearance is so striking that the diagnosis is probably very rarely missed. An enlarged gland in the left hilus or a small sharply localized aneurysm in the descending aorta might conceivably give a similar picture, but in such cases the physical signs would be entirely different.

Syphilitic aortitis unfortunately does not always produce so typical an appearance. Of course it is impossible to detect any roentgen ray evidence of the disease until it has progressed far enough to produce some changes in the shape of the aorta. In a certain number of cases (not over 30 per cent of those coming to autopsy) the involvement is limited to the region just above the aortic valve, and a localized dilatation occurs at this point. Such a dilatation produces a prominence in the ascending aorta just above the aortic valve lesion. The discovery of these dilatations is of great diagnostic value. However, the diffuse dilatations produce pictures which resemble many other conditions, and all of the obtainable clinical evidence is needed in attempting a diagnosis. Figure 26 illustrates such a condition. If the aneurysms had not been discovered, this arch would in all probability have been called arteriosclerotic, and no doubt the patient had definite arteriosclerosis. However, it seems fair to assume that a syphilitic infection general enough to involve vessels in the neck and in the abdomen would hardly miss the aortic arch.

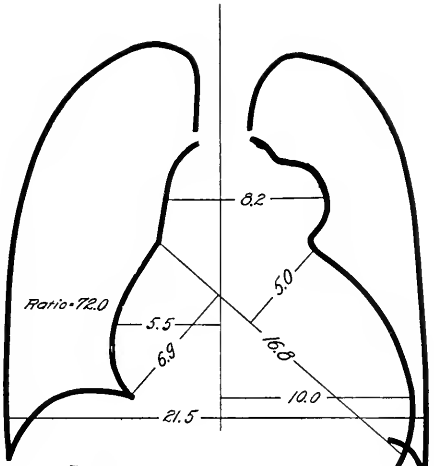


Fig.23

FIG. 23. Dilated Pulmonary Artery. (Case seen at Baylor Hospital, Dallas.) P. H. Mother states that doctors were interested in the child's heart shortly after birth. There have been several febrile attacks of an unknown character.

P. I. Patient is semistuporous and a good history is not obtainable. Mother thinks that patient was fairly well until three months ago when she began to complain of dyspnea and orthopnea. At present she is coughing up a bloody sputum and running a temperature ranging between 99 and 103 degrees F.

P. E. The patient is a fairly well developed negro girl thirteen years of age. At admission the temperature was 103, the pulse 144 and the respiratory rate 46. Râles are heard in the lower left axilla. The left side of the chest is slightly more prominent than the right and a diffuse heaving impulse can be seen covering most of the precordia. The heart is definitely enlarged to percussion both to the right and to the left. A systolic thrill is felt in the pulmonic area. The pulmonic second sound is accentuated and reduplicated. There is a loud systolic murmur heard loudest in the pulmonic area and transmitted upwards on both sides of the neck but best on the left. The white count is 34,800. The urine shows a few hyaline casts and pus cells.

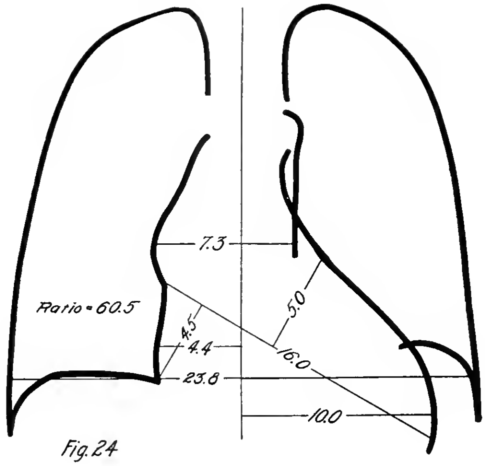


Fig.24

FIG. 24. Specific Aortitis Long Unrecognized. O. P. D. 181357. 1911. Jewish woman of fifty weighing 155 pounds comes in complaining of continual cough with non-purulent sputum, dyspnea, pain in the throat and back, and some incontinence of urine. Examination shows A_2 accentuated, heart not enlarged to percussion, a blood-pressure of 150 (systolic) and the bases of the lungs full of râles. A diagnosis made of bronchitis.

1912. Cough still present. Worse at night. Raises little. Feels weak. No murmurs made out in heart examination. Blood-pressure noted at 130/80.

1913. Cough worse but non-productive. Marked dyspnea on exertion. A_2 greater than P_2. Soft systolic murmur heard in aortic area. Blood-pressure noted as 135/90.

1914. Old symptoms still present. Pain has appeared in left back and in wrists and ankles.

1915. Blood-pressure noted as 180 (systolic). Treated in dental clinic for apical abscesses. Treated in throat room for pain in throat without a definite diagnosis. Treated in orthopedic department for pains and wrists and ankles. All of this treatment failed to clear up original symptoms.

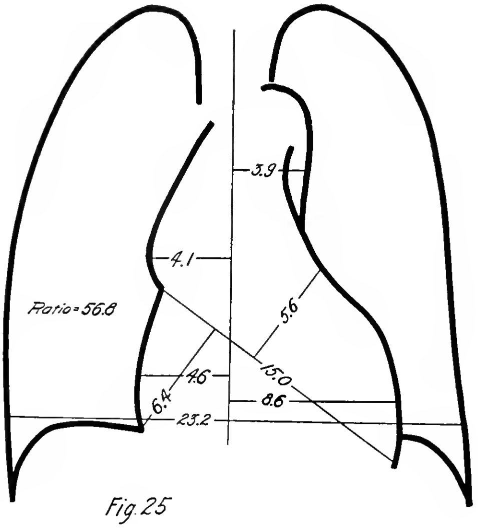
1916. Admitted to the hospital for study. Wassermann negative. Discharged after a week with diagnosis of: Question of cholecystitis, chronic pyelitis, cystitis, and a question of mitral disease.

1917. Admitted to hospital a second time. Discharged with the diagnosis of: Senile heart, chronic arthritis, obesity, and a question of myxedema. Blood-pressure noted as 140/90.

1919. Comes in complaining of hoarseness, cough, a feeling of anxiety, dyspnea, and some palpitation. Examination of the heart shows the sounds regular and distant, a systolic murmur heard all over the precordia and transmitted to the neck, and a diastolic murmur in the aortic area.

DISCUSSION

These few cases show in a general way the more striking morphological differences in various types of cardiac pathology. Prognosis and treatment are now based to a large extent on hypertrophy and dilatation, that is on the condition of the cardiac muscle rather than on the nature of the lesion present. Accurate records of changes in size and shape taken at regular intervals are of the greatest value to the cardiologist. Those who refuse to avail themselves of such aid are merely disregarding one of the more accur-



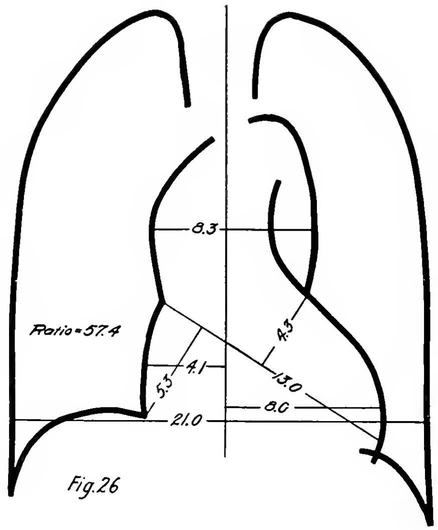


FIG. 25. Specific Aortitis and a Tremor of Syphlitic Origin. O. P. D. No. 392668. P. H. Has had typhoid, scarlet fever, and gonorrhea. Also a penile sore some years ago.

P. I. Slight tremor appeared in left arm five years ago. Remained constant and of the same intensity for three years. It then extended to the left leg and right arm two years ago and has been getting worse. Some shooting pains recently in legs. Otherwise feels well and strong.

P. E. White man. Age forty-three. Weight 140 pounds., Left arm shows a constant tremor. Right arm and left leg show the same phenomenon to a less degree. Tremor diminishes while performing purposeful movements. Right pupil slightly irregular. No reaction to light and distance. Slight systolic murmur in the aortic area. A_2 greater than P_2. Blood-pressure 170/110. Lungs negative. Knee jerks absent.

Laboratory Findings. Blood Wassermann moderately positive. Spinal fluid shows 31 cells per cubic millimeter, an increased pressure, and a strongly positive Wassermann reaction.

FIG. 26. Multiple Aneurysms. Case No. 231966. P. H. No children's diseases. One child lived to be twenty-one but died of tuberculosis. Four miscarriages. "Gastric catarrh" evidenced by abdominal distress and backache for many years. Married thirty years. Says husband is well. No alcohol.

P. I. For past five months she has had an attack of dizziness and vomiting about once a week. Attacks last one or two days. Well between attacks. At times she has a pain in the back which is made worse by exertion and on several occasions has been transmitted down the arm (left) and accompanied by tingling in the fingers. Progressive loss in weight, 70 pounds in four years.

P. E. White woman. Age fifty. Weight 100 pounds. Small pulsating mass felt and seen in the base of the neck on the right side. Systolic bruit heard over this tumor. Firm, round, somewhat tender pulsating mass in upper right quadrant of abdomen about the size of an orange. No bruit heard over this tumor. Heart sounds regular, rapid and of fair quality. A_2 greater than P_2. Slightly accentuated. Loud blowing systolic murmur at the base heard best over the aortic area and transmitted to the neck. No thrills. Blood-pressure 225/140. Arterial walls palpable, tortuous, and markedly sclerosed. Urine shows a slight trace of albumin and a few red and white cells at two examinations. Red count 3,000,000. Hbg. 70 per cent. Wassermann negative.

ate scientific methods at their command.

It may perhaps be wise to utter a word of warning to the enthusiastic roentgenologist who would attempt cardiac diagnosis. Clean-cut cardiac lesions are not particularly common, and the combined lesions that may appear often tax the skill of the best internist with his various methods of investigation. Certain stages in various cardiac disorders produce shapes of the heart outline that are almost identical. If, instead of trying to make a diagnosis, the roentgenologist sends the internist a description of the cardiac shadow and states whether or not it is enlarged and denotes the chambers or vessels which show enlargement, he is rendering a service that is based on sound scientific principles, and one that should be deeply appreciated by the physician receiving the report.

SUMMARY

1. The cardiothoracic ratio offers an easy and accurate method of determining cardiac enlargement.

2. The demonstration of a small heart is often as helpful as the demonstration of a large one.

3. Diseases of the myocardium, endocardium, pericardium, great vessels and kidneys produce cardiac shadows of different shapes, some of which may be used as points in differential diagnosis.

I wish to express my deep appreciation of the assistance rendered me by Dr. Geo. W. Holmes, Dr. William H. Smith and Dr. Paul White. Without their aid and instruction the preparation of this paper would have been impossible.

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AN ANALYSIS OF ELEVEN HUNDRED ROENTGEN EXAMINATIONS OF THE GASTRO-INTESTINAL TRACT*

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In making an analytical study of the symptoms and roentgen findings in a series of cases, there is much additional information that one would seek if it were possible again to marshall the host before him. He would note the previous operations very carefully. He would pin the patient down to some definite, outstanding symptom, instead of accepting the vague replies that are made, as "indigestion," "gas," "general discomfort," etc. So we find in reviewing our cases that there are many points we would like to know. We have tried to work with an open mind, inquiring into these points after our diagnosis was formed, consequently some points were necessarily overlooked.

In this series we try to note the principal symptom, or at least the symptom that drove the patient to seek medical attention. It has been difficult to follow the cases because the work was done in different hospitals, and often the patients came from doctors and surgeons in distant towns and returned to them for treatment; so the operative and clinical findings were not always secured.

There were two conditions that led to this study. First, the frequency of the epigastric pain as a presenting symptom, often resulting from pylorospasm, due to appendix or some other exciting cause. Second, the frequency of the occurrence of chest pathology in the cases presenting gastric troubles. When the study was almost finished I was pleased to hear a paper by Drs. Christie and Groover[1] on this latter subject at a meeting of The American Roentgen Ray Society.

This series of gastro-intestinal cases numbered eleven hundred, and showed the proportion between male and female to be almost equal, women 516, men 584.

*Thesis presented with application for membership in The American Roentgen Ray Society.

TABLE I

PRESENTING SYMPTOMS

Vague digestive and nervousness	390
Epigastric pain	207
Right side pain	180
General abdominal discomfort	139
Gas	66
Biliousness and vomiting	36
Headache and nausea	14
Diarrhea	12
Difficulty in swallowing	11
Abdominal mass	9
Constipation	8
Pain in left side	7
Jaundice	4
Anemia	4
Cerebral symptoms	2
Urticaria	2
Obstruction	2
Vomiting blood	2
Epilepsy	1
Paralysis agitans	1
Rectal pain	1
Loss of weight	1
General arthritis	1
	1100

In the series the largest number, 390, came complaining of general indigestion, or indigestion and nervousness and malaise. They are classed in the table as "Vague Digestive". The next in frequency was 207 epigastric pain. These cases varied from intense hunger pain to the vague discomfort, and include those subjective symptoms upon which the clinician usually bases his diagnosis of ulcer.

Following this, we find right side pain with 180 cases. I have not attempted to classify this symptom. It includes the pain, front and back, high and low, on the right side, and the number seemed sufficient to demand attention. Of the physician's *bête noir*, left side pain, I note only seven cases.

Next we notice a symptom that is really rather common, general abdominal discomfort, with 139 cases. This, like indigestion, covers a multitude of sins, varying everywhere from a fullness to a diffuse, general pain, a complaint which is even more common than this number would indicate. While in this series there are only ten or fifteen colored patients, we might say that one rarely sees a patient of this race from whom this symptom cannot be elicited.

Following this come 66 cases with a group of symptoms that the general practitioner meets frequently. The patients give a list of symptoms generally starting with "gas," "sour stomach," "heart burn," "belching," etc., and if they are "fair, fat and forty" the clinician thinks of some gallbladder trouble.

The next 36 cases present symptoms that also sound familiar—frequent bilious attacks with vomiting of bile and often nervousness and sick headache.

The other symptoms shown in Table I need no discussion since they represent a rather large variety and very few are of special interest.

Now in regard to the roentgen findings, since some cases present two or more pathologic conditions which are difficult to tabulate, but where a certain condition is the most noticeable, this is chosen. There are only 107 cases reported as negative, but if the list were culled carefully other cases would fall under this head, since findings were reported other than those which pertain to the gastro-intestinal lesions.

While the most frequent diagnosis made is the appendix, and while I am fully convinced that it does influence the digestive tract, the writer agrees with Pfahler[2] and others in regard to this much maligned organ, and believes that if the patient with a barium meal is constantly watched, at some hour during its passage the organ can generally be demonstrated. But here I have classed as chronic 117 of the 301 cases, these being the cases that showed adhesions, tenderness or constriction, or that retain barium some time after the cecum is emptied. The 141 that are reported as simply patulous, while they were not pathological were conceded to be potentially so. Furthermore, those combined with stasis and ulcer were most probably of the chronic type. It is interesting to note that 33 per cent of duodenal ulcer cases were accompanied by a patulous and chronic appendix. Attention of the gastro-enterologist and surgeon was called to this and in many cases a pathological appendix was found. Certainly the occurrence is frequent enough to suggest to us the plausi-

bility of a theory as to the cause of duodenal ulcer, viz., that the chronic appendix reflexly causes a pylorospasm or duodenospasm, and that this is followed or accompanied by a hyperacidity, possibly causing or contributing to an erosion which gives a seat for the invading organism.

Of the class of cases, numbering 46, diagnosed as dilated duodenum, which showed as a rule the symptoms outlined by Vanderhoof[3]—nausea and vomiting, bilious attacks, headaches and nervousness—many were due to extreme ptosis of the stomach, some to adhesions, and one or two were accompanied by lordosis. Only one was of the extreme type referred to by Engelbach[4] and I believe only one came to operation.

In regard to chest conditions, although they are amply sufficient to demand consideration, we do not have quite as large a percentage as in the series of Christie and Groover.[1] This is possibly due to the fact that only in the cases in which routine fluoroscopic observation seemed to indicate did we make a plate for careful study. The lungs showed pathology in 47 cases and the heart and aorta in 29 cases, giving a little over 7 per cent in which the chest pathology was at fault. This does not include many cases in which there was pathology here and a frank lesion in the alimentary tract, but only those cases in which this condition was the principal lesion observed.

In our laboratory it is almost a routine to examine the teeth, certainly any suspicious ones. And in these thirty-one cases, while the rest of the alimentary tract was negative, they were considered sufficiently bad to suggest that they might be causing some trouble.

In regard to the liver and gallbladder region, the pathology was located here in 110 cases; 35 of these carried a report that we dislike to give—"suspicious gallbladder," but since evidence was not conclusive this term was used. I am unable to say how many of the 22 reported as gallstones were confirmed by operation, certainly the majority.

The frequency of cancer in this series has been striking, but this I believe is explained by the fact that our clientele comes from a large area of country, and that, as is well known, these cases go to specialists only as a last resort.

TABLE II

ROENTGEN FINDINGS

Negative		107
Appendix		301
with ulcer	21	
with stasis	22	
chronic	117	
patulous	141—301	
Stasis colon		79
Stasis small intestine		4
Spastic constipation		53
Duodenal ulcer		28
Gastric ulcer		28
Pylorospasm		18
Dilated duodenum		46
Gallstones		22
Suspicious gallbladder		35
Cholecystitis gallbladder		39
Kidney stones		9
Cancer		55
Gastric	32	
Colon	7	
Rectum	2	
Gallbladder and liver	9	
Esophagus	4	
Pancreas	1—55	
Cardiospasm		6
Diverticulum of esophagus		1
Dilated heart and aorta		29
Pulmonary tuberculosis		47
Bad teeth		31
Intestinal obstruction		2
Pyloric stenosis		2
Colitis		31
Gastritis		2
Duodenitis		2
Incompetent ileocecal		13
Ulcer rectum		3
Adhesion ileocecal		23
Abscess sub-diaphragm		2
Abscess liver (amebic)		1
Abscess pelvis		1
Abscess spleen		1
Ptosis stomach		20
Ptosis colon		7
Ptosis intestines		9
Ptosis kidney		6
Syphilis stomach		9
Syphilis liver		2
Pelvis tumor		1
Hernia with adhesions		3
Hyperthyroid		7
Redundant colon		2
		1100

Under the head of pylorospasm, used here in the sense of irritable or spastic, there are only 18 cases. There is always a cause for this condition but these represent the cases in which no cause was located. My observation has been that it generally manifests itself in epigastric pain, which brings me to the study of the 207 cases presenting this symptom. (See Table III.)

TABLE III

EPIGASTRIC PAIN

Chronic appendix	75
Duodenal ulcer	44
Gastric ulcer	18
Pylorospasm	14
Duodenal ulcer and appendix	15
Gastric carcinoma	7
Gallbladder with pylorospasm	6
Kidney stones with spasm	5
Cecal adhesions	5
Spastic constipation	5
Bad teeth and spasm	4
Negative	4
Dilated aorta	2
Duodenitis	2
Dilated duodenum	1
	207

Of the findings in these cases the ulcer cases, carcinoma, and possibly the cases of duodenitis, or about 86 cases, would cover those having sufficient lesion to explain the pain. In the remaining 121, the pain must have been due to pylorospasm; in all but 14 there was some cause found, and I feel that if a closer study could have been made in the cases marked "Pylorospasm" alone, the cause might have been determined. It is striking to observe how many cases of chronic appendix were observed here, also the frequency of the location of the lesion elsewhere, as kidney, gallbladder, and colon.

There are many other interesting points that have arisen in the study of these cases, but it is not necessary to mention them at this time.

I wish to thank Dr. W. O. Nisbet and my other associates for their assistance in working up these cases.

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CONGENITAL ATRESIA OF THE ESOPHAGUS*

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THE rarity of case reports upon congenital atresia of the esophagus in roentgen literature prompts a report of the following case seen in consulation with Dr. Frank C. Neff, of Kansas City.

In this condition the upper third of the esophagus usually ends in a blind cul-de-sac which is often dilated (Adami, Page 397). The lower part may be absent completely, or the lower portion forms a fistulous opening into the trachea or bronchus. The embryological explanation of these cases is lacking. Cautley classifies malformation of the esophagus into eight general divisions. His article is quite expansive and it should be consulted by anyone interested in following up this kind of case.

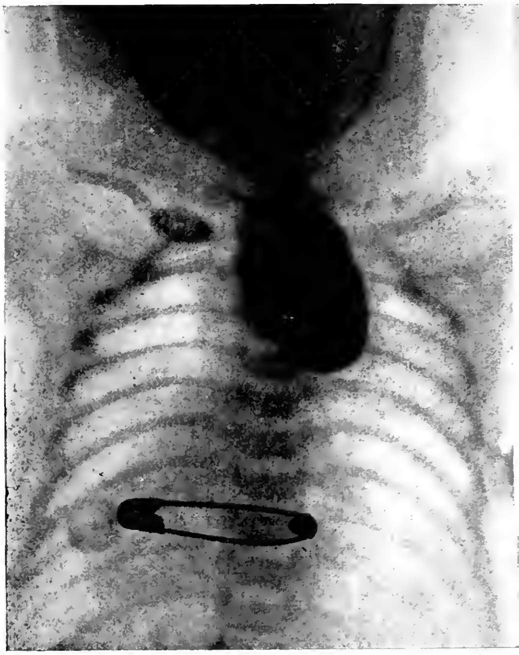

FIG. 1. Antero-posterior projection showing complete obstruction of the esophagus above the atresia with dilatation.

Fig. 2. Oblique projection showing the same condition.

CASE REPORT

Baby V. H., girl, born October 25, 1920, weight six and one-half pounds. Four brothers living and well; one sister dead, cause not known. Parents well. This child was two weeks premature, but delivery was normal. Vomited all the milk immediately after each breast nursing.

This baby was seen in consultation upon the fourth day of life and appeared to be well nourished, with a grunting respiration and normal temperature, no pyloric tumor, no peristaltic wave, and with a history of having vomited every nursing, although the child appeared to be hungry and nursed eagerly.

The little patient was brought to the laboratory sandwiched between two hot water bottles. Barium was mixed into breast milk in a nursing bottle. The baby eagerly nursed this from the bottle. The fluoroscopic examination showed a cul-de-sac formation reaching just below the clavicle to the level of the fourth dorsal vertebra. It was of a character and size frequently seen in adults suffering with a Zenker's diverticulum. The lower

*Read at the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

margin of this pouch was smooth and rounded with absolutely no evidence of any canalization of the lower two-thirds of the esophagus As soon as the cul-de-sac was filled with the barium suspension the child began to vomit but did not relieve the cul-de-sac entirely.

The attached illustrations were taken in the dorsal position of the patient and in the antero-posterior and lateral planes. They represent quite exactly the size and outline observed with the fluoroscope.

The subsequent history of the case is brief. Inasmuch as inanition was imminent and complete obstruction apparent, a gastrostomy was performed the following day and the baby lived forty-eight hours following the operation, during which time two teaspoonfuls of breast milk and warm water were fed through the fistulous opening into the stomach every hour.

The autopsy revealed that the esophagus ran down to the level of the bifurcation and ended in the form of a pouch with a fibrous band attaching it to the trachea. Extending up from the cardiac end of the stomach was the lower portion of the esophagus with a patent lumen for about 2 cm. At this point it disappeared, becoming fused with the mediastinal tissue. The stomach was small but of normal development.

This case corresponds with type 7 (b) as classified by Cautley.

There have been two case reports of the atresia of the esophagus in American pediatric journals, which also carry roentgen illustrations. These are cited in the following bibliography.

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DISCUSSION

Dr. A. W. Crane. Some years ago we had a case of atresia of the esophagus which was exactly the same as the case just reported. After the baby's death we brought the body to the office and did a postmortem. We injected a barium mixture into the stomach through the pylorus. This mixture filled the esophagus from below, and when *x*-ray plates were made, an anastomosis of the lower esophagus with the trachea became apparent.

There have been quite a number of cases reported at the Chicago clinics. In all of these, so far as we have records, a communication between the lower portion of the esophagus and the respiratory apparatus was found. Death would of course invariably result in all of these cases.

Dr. L. T. LeWald. We had a case of this sort in which demonstration was made by a catheter passed into the esophagus, and then an *x*-ray exposure was made which showed the point of obstruction.

In all the cases of this sort observed at the New York Lying-in Hospital there was a communication between the lower portion of the esophagus and the respiratory tract.

I would like to ask Dr. Skinner if there was any communication in his case?

I know of four or five cases which have been operated upon unsuccessfully because the communication between the stomach and the respiratory tract was not recognized. The surgeon should close the cardiac end of the stomach in addition to performing a gastrostomy.

Dr. E. H. Skinner. Replying to Dr. LeWald; there was no trachea-esophageal fistula in this case. Such types are, however, more frequently encountered.

X-RAY WORK FROM THE VIEWPOINT OF AN INTERNIST

By GEORGE DOCK, M.D.

ST. LOUIS, MISSOURI

I CANNOT appear before this body without thanking your President for the honor conferred on me by the invitation. Coming from him, it seemed a command as well as an invitation, for I am under an old debt of gratitude to him for his keen and enthusiastic cooperation in my clinic before he took up the work to which he has since devoted himself with great success.

I have other reasons for appreciating the invitation to address your meeting. I have had a long-standing interest in *x*-ray work and have been in almost daily contact with roentgenologists since I was initiated into the possibilities by such masters as Crane, Hickey and Hulst. Nor can I forget that cheerful co-laborer, Vernon Willey, whose death cut short so much promise. Later I had the association of the genial Granger in New Orleans, and of Russell Carman and Walter Mills here. I began with the crude fluoroscopy of the earliest days, guided by technicians skilled only in electricity and photography, but soon I realized the great extent and seriousness of the subject and was glad to depend upon experts with whom I have long worked intimately, combining thus the clinical and radiological points of view.

I shall speak chiefly from the clinical standpoint, but as one who finds radiology as indispensable as percussion or the microscope, and demanding the same devotion to make it a success. This leads to some consideration of specialists, concerning whom so much has been said, and so much that is contradictory. The contradictions have often been due to the differences in specialists and specialties, and those relating to roentgenologists will be repeated in the case of many other technical methods in future as they have in the past.

Novelties in medical diagnosis are taken up and cultivated by people of all ages and degrees of experience or inexperience. If the work is of a kind requiring not only skill, but also complex, costly and rapidly changing apparatus, it cannot be taken over generally as can simpler methods. We can compare physical diagnosis or urinary microscopy and the simple urine chemistry on the one hand with serology, radiology and blood chemistry on the other. The work then forms not a medical specialty, like ophthalmology or internal medicine, but a technical specialty. If the one who cultivates it has little or no medical training he remains a technician unless by a combination of mental gifts, opportunity and hard work he acquires the other necessary knowledge. The more widely experienced man who cultivates a new technical method, acquires the physical equipment and uses it along with his other methods, becomes of course a broader and more efficient man than he was before, a higher type of specialist. If he chooses to hand over the more mechanical part of the work to an assistant or servant, he is still at an advantage over those who have all that he has except the finished technical knowledge, just as he also has an advantage over the technician, no matter how much of a virtuoso the latter may be. If such a man as I have described has a fairly large amount of work, if he does original investigating, keeps up with the literature of the subject, attends special meetings, visits other laboratories, imparts his knowledge to others through addresses, articles and books, he occupies just as important a position as any specialist and will have the same sort of recognition. At another end of one class we find a specialist who cultivates roentgenology only as an aid to his clinical work—the tuberculosis specialist, gastro-enterologist, etc., whose work will be legitimate if it is good.

As in other lines of medicine the difference in the ability of roentgenologists is not

*Read at the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

known by the public, or even by all physicians in their spheres of activity. So we see men asked to make diagnoses or to do operations for which they are not fitted; to refuse to act is sometimes more than human nature can stand, but consent is fraught with danger to patient and reputation. Not even organizations such as special societies or national "colleges" can stop this, nor probably anything else except greater enlightenment and publicity regarding medical work.

There is room in every city of considerable size for roentgenologists of the highest type. Other specialists will be glad to obtain their services in many cases. Family physicians and general practitioners must constantly call on them for assistance. But many such specialists will suffer from the necessity of covering too large a field ever to become preeminent in any one department, such as bone, chest or gastro-intestinal work. It will probably be best for the roentgenologic specialist to specialize still more, and it would be well, where there is more than one in a city, for each to restrict his work to the line or lines in which he is most skilled. In this, as in so many other aspects of medical life, cooperation offers the most desirable conditions for work, and a group of roentgenologists might also be part of a larger and more varied group of specialists, until they form the most complete team.

Roentgenology furnishes an interesting light on changing conditions in medical economy. Formerly hospitals and medical scools were the nurseries for new and developing technical methods and technicians, but both these kinds of institutions are likely to have restricted budgets, and it is often impossible for them to furnish the few or many thousand dollars necessary to equip and conduct such a thing as an x-ray department or a radium supply, just as it is impossible to equip and conduct a chemical laboratory or modern bacteriological laboratory or heart station. Those who work in universities, as a rule, have no private capital for such purposes, and so the demands can usually be met only by specialists with large practices, or by groups of specialists with initiative as well as credit.

Leaving this rather material but essential phase of the subject, let me consider another. An important fact about medical diagnosis, often overlooked, found in x-ray as it is in other kinds of work, is that positive findings are, as a rule, of limited application, and must be combined with others to give them clinical value. It has taken a long time for physicians to recognize these truths, and many do not bear them in mind even now. For centuries there was a search for pathognomonic signs, and these were but slowly relegated to a subordinate place as their lack of certainty was demonstrated; but each new method still revives the same sort of hope. Dozens of methods of percussion have been devised, and hundreds of stethoscopes invented, with the hope that each one would give unequivocal results. Hundreds of men worked at urea determinations believing that if they could only get the right method they would end all trouble in the diagnosis of protein metabolic errors, gout rheumatism and what not. Men have deluded themselves into searching for cancer cells, for cells characteristic of limited areas, such as the ureters and the renal pelvis. Even now, although the fallacy has been known for years, men will titrate for hydrochloric acid in stomach contents, solely to recognize or exclude cancer of that organ, and for some years many will think that a basal metabolism determination will save all the minute examinations of a large and varied clinical material. In roentgenology, many had an idea in the beginning that with its aid one could do for a gastric ulcer or tumor what the gastroscope had failed to do—make it it visible as certainly as the ophthalmoscope makes retinal hemorrhage or a choroiditis visible.

The truth is that discoveries in diagnosis do not shorten or make easier the work of diagnosis. They make it more accurate, they make it fuller, but only by enlarging the manual work of the diagnostician and calling for a greater capacity for generalizing. The

same sort of disappointment followed the finding of tubercle bacilli that so often follows the fluoroscopy or skiagraphy of the thorax in certain cases. In each case one hoped that the tedious task of history-taking, physical examination and repeated physical examination and of laboratory tests would be avoided. The dream was, and still is, to endeavor to detect and treat the disease, instead of treating the patient. Very slowly do the real facts appear, and these have different values for each method of manipulation. So the finding of tubercle bacilli in the sputum is positive evidence of tuberculosis, but where, how much, in what form or stage, how virulent and all the rest of the patient's condition, must be worked out by other methods. The finding of elastic tissue in sputum was once expected to do what it was later hoped tubercle bacilli would do—shorten the task of diagnosis. It was long since abandoned for that purpose, and is not used now as much as it should be, for it is easy to find when present, and when found gives proof of a fact that cannot be demonstrated as certainly in any other way, including the use of *x*-rays, viz., the breaking down of the lung, or cavity-formation. But here too the situation and extent of the breaking down must be worked out by other methods, including roentgenologic ones.

Here I may be allowed to comment on some of the features of lung diagnosis with reference to *x*-ray work. The application of *x*-rays to lung pathology was no greater innovation in its time than the use of percussion and auscultation a century earlier. Both the latter became useful very soon after they were applied, because they had been tested by the results of other clinical methods and of postmortem examination by their discoverers and others. Not only what they could reveal, but what they could not reveal, were made clear within a short time of their application. Only details were added later, and these depended upon other new technical methods, or upon additions to pathologic anatomy and etiology.

Roentgenographic methods as applied to the lungs do not differ essentially from auscultation and percussion. All depend largely on differences in density of the structures concerned, and on physical facts relating to density. There is another similarity. Auscultation and percussion are strongly personal methods, affected by the special senses, tact and technical skill and by experience and accurate thinking on the part of the examiner. I think that in roentgenology the same qualities are all necessary, with the additional drawbacks of the freaks of machinery and electric currents, of screens, plates and reagents. The same things that affect auscultation and percussion in the body of the patient—thickness of chest wall, size of thorax—affect the fluoroscopic picture and the skiagram. I think it is a fact that *x*-ray work on the lungs was not controlled by anatomic investigation to the same degree that auscultation and percussion were. This was due partly to a general decline in postmortem examinations that seems to be getting worse instead of better, and further due to conditions too complicated to consider in detail at this time. But it depended also, I think, very largely on the fact that many *x*-ray specialists had little knowledge of lung diseases, and especially had no familiarity with either the gross or microscopic conditions in lung diseases. Yet on account of the striking results of *x*-ray examinations of bones, early roentgenologists were forced into the position of lung diagnosticians with extraordinary powers.

The sources of difficulty in roentgenologic examinations of the lungs did not, in the beginning, and do not now seem to be recognized as accurately as they should have been and should be. For example, with percussion it was easily shown that in order to alter the percussion sound, a lesion must reach a certain size and lie within a certain distance from the chest wall, and with recognizable sources of confusion in the chest wall itself. With *x*-ray work many technicians assumed from the beginning that all lesions could be made out in the screen or plate, and boldly made diagnoses of things they had never seen before. In the beginning inferior screens and imperfect technique

were unavoidable. With inferior technique the *x*-ray plate gave a set of silhouettes of planes showing areas of varying density superimposed on each other. With better technique, including the stereoscope, it gave an infinite number of perspective views superimposed. In both cases something between one third and one half of the field were obscured by those dense structures, the ribs and heart. Yet in spite of these difficulties much excellent work was done—much work of very great value clinically—and for this result the small number of close students of anatomic and *x*-ray examinations and a comparatively small number of talented and cautious technicians must be thanked.

X-ray methods should be applied much more freely to the study of lung diseases than they are now, not only for the certain additions they will make to knowledge, but for their practical value. They can confirm many points disclosed—but not fully enough—by auscultation and percussion. They make clear in certain cases that what had been a bronchitis is really a pneumonia or some other process affecting the air cells or the blood vessels, lymphatics or interstitial tissue of the lungs. They can reveal a process that was often suspected on using older methods, but could not be proved by them, such as an infiltration of an inner edge of a lung, or an effusion between lobes not reaching the surface to an extent permitting recognition by percussion.

They have shown the not infrequent existence of small pneumothorax cavities in various parts of the thorax. This may not be as important a finding as some others, but adds much to our knowledge of thoracic pathology. But here one may mention an important clinical fact, the kind of fact that cannot be lost sight of in discussing diagnostic technique. Any one with a rather wide observation of *x*-ray reports on thoracic cases will see some in which even a large pneumothorax is not recognized in the fluoroscopic plate, though it may be by physical signs, and on the other hand, cases are said to have pneumothorax when further *x*-ray and other examinations show nothing more than an artefact.

Another condition not yet investigated by roentgenologists as much as it deserves, is atelectasis, including the interesting form described as massive collapse of the lungs (W. Pasteur and others).

Physical diagnosticians always lay stress on repeated examinations, having learned that a single one is likely to be incomplete. In striking contrast to this is the confidence with which many *x*-ray specialists will make a positive diagnosis from a single examination and sometimes a prognosis. Even more, patients are ordered to Arizona or California upon the finding of an enlarged hilus shadow or of density in the apex, without further inquiry.

Physical diagnosis is notoriously beset by the perils of a strong personal equation, and physical diagnosticians are rightly expected, by those who seek their help, to explain on what grounds they base their conclusions. The personal equation in the interpretation of *x*-ray findings is present too, though perhaps not to so great an extent; and yet we find *x*-ray specialists who refuse to show plates to physicians consulting them, but hand out ex-cathedra diagnoses from which there is no appeal. I admit this is rather uncommon, but that it exists imposes upon the specialty the task of reforming its practitioners.

The *x*-ray specialist is at a serious disadvantage in the matter of following up cases. In physical diagnosis we learn much, in cases not coming to autopsy, from the sequence of events. But the *x*-ray operator can only do this with inconvenience to the patient—sometimes impossible to overcome—and expense to someone. This matter of expense is one of the most potent causes of the backward condition of thoracic *x*-ray work. If *x*-ray plates were as easy to get as temperature charts how rapidly could we enlarge the comparison of *x*-ray and anatomic results, as shown by the valuable serial study of influenza-pneumonia by Sante! But the cost of material and the time of technicians pro-

hibits this work almost wholly. The difficulty of financing such essential work, in contrast with the ease of financing measures for destroying life, is one of the most depressing phenomena of the time we live in.

Among unscientific practices in *x*-ray work on the chest may be mentioned the unfounded confidence on the part of many in the interpretation of shadows of the hilus region. All who have had postmortem experience know how often the glands in the roots of the lungs become enlarged. They become so by congestion and edema in many cases of bronchitis and bronchopneumonia; they become so on account of tubercles, many of which heal, leaving calcified or fibrous areas very often; they become so on account of various causes of irritation, many of which leave no other evidences of danger than the enlarged shadows. I have often been told of cases or have seen reports in which such enlargements were given an exact etiologic name; viz., tuberculosis, but I have never had demonstrated the grounds on which the diagnosis had been made, except as regards calcification.

Pathological-anatomists are also familiar with many cases in which there are areas of disease of varying sizes, from those barely visible to the naked eye up to the size of hempseed, that cannot be differentiated by the naked eye, and under the microscope cause much difficulty. These are especially bacillary tubercles, gummas, miliary carcinomas and lymphomas, but sometimes actinomycotic granulations or other processes. All of these and some other dense areas that I cannot explain are likely to be called miliary tubercles if they show on the screen or plate. It is not less surprising to see the confidence in the diagnoses than the belief that the diagnosis of miliary tuberculosis, without further qualification, is of any great value.

Anatomists know that miliary tubercles may occur in very small numbers, so that they might be visible singly on the plate. But these are often of slight clinical value. They occur in that form either as terminal lesions in fatal cases, or heal without having been suspected during life. Clinically, miliary tuberculosis of the lungs is well known, though not always easy to recognize. In the great proportion of cases in which I have known the *x*-ray diagnosis to be made, it has not been borne out by the further course of the disease, if favorable, or the autopsy, if fatal, and in many cases fairly extensive tuberculosis has been present without being suspected by the radiologist.

Larger areas of density in the lungs are also frequently asserted to be tuberculous, but I am not aware of any criteria by which one can distinguish between, let us say, catarrhal lobular pneumonia in influenza or other conditions, tuberculous bronchopneumonia, and other similar focal processes. A fact familiar to all clinicians who utilize *x*-ray work, but too often overlooked by technicians is that very often pin-head or hempseed sized lesions are shown on the plate, but larger ones may be missed, even up to those that give physical signs. It is interesting to see that the *x*-ray diagnosis of cavity is still missed in both senses—diagnosed when not present, overlooked when present in considerable volume.

A common mistake made by *x*-ray operators is often made also by physical diagnosticians. There is some excuse for it, as the mistake was once made by Laënnec himself, but it should be avoided by a habit of caution. The situation is as follows: A patient known to be tuberculous, or found to have a suggestive history and signs of a lesion in one apex or both, shows signs of a bronchopneumonic process in one or both of the lower lobes, or even more. The *x*-ray plate, like the auscultation, shows a widespread bronchopneumonia. It is assumed to be a peribronchial tuberculosis or bronchopneumonia and a bad prognosis is given on account of the wide extent, but it may be a simple coccus inflammation of mild virulence and may rapidly clear up, with much adverse comment on the part of those who observe the obvious mistake.

This reminds me of the frequent note "active" in connection with a diagnosis of tuberculosis by *x*-ray specialists. I have never

had anyone demonstrate the reason for such a diagnosis when based on a single examination. One can say that a calcified area, on the other hand, is evidence of an old lesion. Most probably it is inactive, yet it may liberate viable bacilli at some time and become active. The work of Opie on calcification in the lungs and other organs should be carefully studied by radiologists, not merely for the technical bearings, but even more on account of their relation to prognosis.

I also view with scepticism the x-ray diagnosis of tuberculosis of an apex, since the only tuberculous lesion likely to agree with the diagnosis is an obsolete one, in which no one can predict renewed activity. Auscultation, I think, is much more trustworthy in apex lesions, though the skiagram should always be made, preserved and compared with later ones. The methods of apical roentgenology offer a striking contrast to those followed in gastric, duodenal and gallbladder work.

X-ray examinations are indispensable in the accurate recognition of all chronic diseases of the lung and pleura, and especially bronchiectasis and encysted old pleurisies with or without fibrosis, but without the exploring needle the latter cannot be understood. In these two conditions x-ray specialists can learn much from thoracic surgery, and it is to be hoped that all cases suitable be carefully studied before, at, and after operations on lungs and pleurae.

Roentgenology is indispensable in the diagnosis of aneurysms, for some can only be recognized in this way and even those made out by the physical signs can be more completely explained by x-ray examinations. Yet even in this field there are sources of error that the mere technician will do well to bear in mind. The heart and pericardium furnish another field deserving careful collaboration between roentgenologists and anatomists. I have seen one of the former make the same mistake that sometimes befalls the physical diagnostician—take a pericardial effusion for enlarged heart, because the cardiohepatic angle was not obliterated, as it is supposed to be with effusion, but is not always.

The great field of dental radiography furnishes many illustrations of the fact that it is still in the stage of development. Experts are too prone to give positive statements of films or plates alone, sometimes missing quite important lesions, then again ordering removal of teeth, a problem purely dental.

Some old errors are certain to be repeated in the interesting field of pneumoperitoneal fluoroscopy and skiagraphy. One can make out organs beautifully; one can detect many small foci of disease on the surface, but histologic features will not be cleared up, so the need of exploration cannot be avoided. The same sorts of mistakes that have been made through relying on examinations of ascitic fluids will be made in this variety of roentgenologic work, if it is depended upon alone.

The great advances in gastro-intestinal fluoroscopy and skiagraphy, intestinal ulcerations and adhesions, and especially diseases of the stomach and duodenum, bile tract and appendix, throw a flood of light on the methods of improving all departments. I have spoken of the need for autopsies in clearing up lung diagnosis. In gastro-intestinal work we have the invaluable cooperation of the surgeon in very many cases, so we owe him, as well as the physiologists who have added so much to the subject, thanks for a great part of the advance, and we should keep in close touch with all operative procedures on "*geröntgt*" patients, in order to have a vivid picture of actual conditions.

Your President has asked me what undergraduates should be taught about x-ray work. That is a large and very important question. I will simply tell what we do here without wishing to be understood that we think we have reached finality either in methods or results.

Our students are given demonstrations in the anatomical course showing the use of x-rays in embryology, bone development and evidence of age in growing bones. It is used

by Dr. Opie in the teaching of pathology. I take the class in the second third of the second year, with a course in physical diagnosis, and use selected plates to show types, especially of the thorax, variations of position of thoracic organs in health and disease; position of stomach and intestines. As the members of the class percuss and auscult each other, and make diagrams of the results, we select a group of various shapes of heart dullness, and various heights of diaphragm, mark out the percussion lines with lead strips and take seven foot plates in the same quiet breathing in which percussion was done. These are placed before the class in the following exercises. If we find anything abnormal in these healthy subjects, such as signs of old pleurisy, valvular lesions, etc. we get plates and demonstrate in the same way. We do not allow the class to use the fluoroscope on account of the number (thirty-five) and the risk of prolonged exposure from over-enthusiasm or of waste of time from too brief observations. In this same class we show the skiagrams of patients who have been seen and palpated for pleural friction, thrills or aneurysmal pulsations, of those who have been demonstrated with dullness from pleural effusion, then tapped, with plates taken before and after, and demonstrations of the resonance in the cleared area.

In the third and fourth years we study with the class or groups all the plates of patients seen in out-patient department and wards. Students spend three months each year in each division of Medicine, Surgery and Gynecology-Obstetrics-Pediatrics, see plates of many of the cases under their care, and have an opportunity of seeing fluoroscopic examinations of many lesions such as esophageal stricture, cardiospasm, gastric and duodenal ulcer, gastric carcinoma, colon diseases, including diverticulosis. I should add that we take tuberculosis patients in all stages (in limited numbers) and are able to study the *x*-ray features as thoroughly as possible.

My colleague, Mills, gives a series of demonstrations of diagnostic work in abdominal disease, and he, as well as Dr. Sherwood Moore, offer optional courses in *x*-ray diagnosis and technique.

In other departments equal importance is given to the study of plates and fluoroscopy, the bone and cranial work occupying a very large field.

No practical work with tubes is given, except to individuals with spare time and sufficient preliminary training, or in special courses.

We consider knowledge of *x*-ray evidences of disease essential to the graduate, but think technique and original diagnostic work should be taken up by a course of apprenticeship later on, though it may begin in the interne year. In other words, we think every student must know how to use a laryngoscope and ophthalmoscope, to know the elements of bacteriology and serology, but that not everyone as an undergraduate can learn how to use *x*-rays, or for that matter cystoscopes, bronchoscopes, Wassermann technique and many other matters.

As many of you heard the outline of graduate education by Dr. Louis B. Wilson at the September meeting of the society, and all have probably read it in the December number of the Journal, I need do no more than express my admiration for the course proposed and congratulate those able to follow it.

THE INTENSITY OF SCATTERED X-RAYS IN RADIOGRAPHY*

By R. B. WILSEY

Communication No. 102 from the Research Laboratory, Eastman Kodak Company

ROCHESTER, NEW YORK

SCATTERED radiation is the only type of secondary x-rays which is an appreciable factor in medical radiography. The fluorescent or characteristic radiation from the chemical elements of low atomic weight, such as make up the human body, is negligible. Even the fluorescent radiation from most metals when exited by primary rays of the usual radiographic quality (corresponding to a 5 inch spark-gap) is so soft and of such low intensity that it does not noticeably affect a film through the ordinary cardboard holder or paper envelope.

Most of our information about scattered x-rays is from the investigations of Crowther, Barkla and his associates, and Hull. In the study of the fundamental laws of the scattering of x-rays, their experiments were performed with relatively thin sections of matter, in order to minimize such effects as absorption and re-scattering of the scattered rays. The principal conclusions reached by these investigators on the scattering of x-rays by the lighter elements may be summarized as follows:

1. The scattered radiation from an element is independent of its physical state and its chemical combination.
2. All wave-lengths of x-rays (within the the range usually employed) are scattered equally; in other words, the hardness of the scattered rays is equal to that of the primary beam.
3. All substances of the class considered scatter x-rays equally mass for mass.
4. The scattering is greater in the direction of propagation of the primary beam than in the opposite direction, and it is greater in either of these directions than in directions at right angles to the primary rays.

In the light of these facts, the best advice has been to use diaphragms to reduce the scattered radiation in radiography, the usual procedure being to limit the volume of matter rayed by means of a cone or diaphragm between the tube and the scattering material.

There has been practically no systematic investigation of the behavior of scattered x-rays in large volumes of matter. On account of the considerable effect of scattered radiation in reducing contrast and obliterating detail in the radiographs of thick parts, the present investigation was undertaken to study the scattering of x-rays from the standpoint of practical radiography. While we may generalize to some extent on the effects of various factors in technique upon scattered radiation, the lack of quantitative data has prevented any effective analysis of the problem. In the present work the problem of scattered radiation has been approached in two ways, first by measurements of the *intensities* of scattered radiation under various conditions, and second by the *effects* of scattered radiation upon contrast and definition in radiographs[1]. The aim has been to determine the relation of the various factors in the radiographic process to scattered radiation; these factors include those under our control, such as tube voltage, filters and diaphragms, as well as those factors which we cannot ordinarily change, such as amount and distribution of the scattering material.

The effects of scattered radiation can be foretold to a considerable extent if we first know the relative amounts of scattered rays and primary focal rays reaching the plate or film. As a rule, we are apt to judge the amount of scattered radiation affecting a radiograph by the contrast. This is not fully justifiable since the contrast depends to a certain extent upon the character of the photographic material used, development

[1]The data on the effects of scattered radiation will be presented in another paper in the near future.

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14-17, 1920.

conditions, etc. A radiograph can be copied in such a way as to obtain a negative of much greater contrast than the original. Obviously this process does not affect the scattered radiation which was incident upon the original radiograph, although it may overcome the loss of contrast produced by the scattered rays. The method used in the present experiments measured the relative photographic intensities of scattered and focal radiations incident upon the film independently of any contrast effects. The term "photographic intensity" refers to the intensity as evaluated by the photographic material used, as distinguished from the value

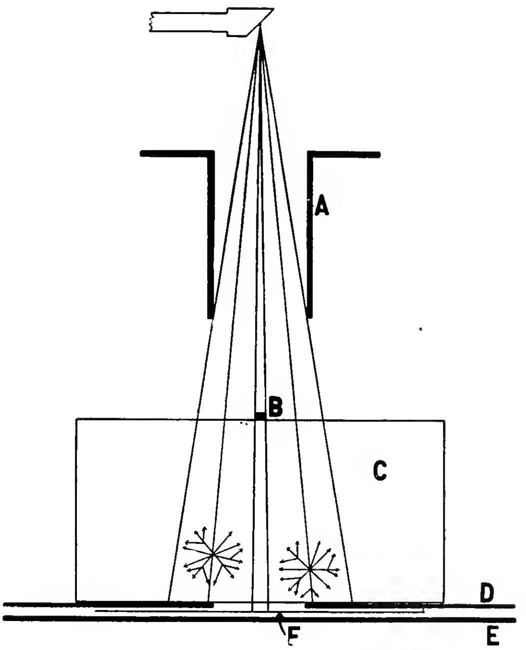

FIG. 1. Diagram showing experimental arrangement for the determination of the ratio of diffuse to total radiation. *A* is a lead cone; *B*, a small lead disk; *C*, the scattering material; *D*, a lead diaphragm between the scattering material and the film; *E*, a sheet of lead beneath the film *F*.

which might be obtained in recording the radiation by some other means, such as an ionization chamber, a fluorescent screen, or a different photographic material. The evaluation of photographic intensity therefore depends upon the way the photographic surface integrates the intensities of the various wave lengths of radiation incident upon it.

The experimental arrangement is illustrated in Figure 1. A thickness of scattering material C was placed over the film F. A lead disk, B, 5/16 inch in diameter by ¼ inch thick, was centered over the scattering material. The only rays which could fall in the shadow of the lead disk were scattered rays and primary rays from other parts of the target than the focal spot. Both types of radiation will be included in the term *diffuse radiation,* while the primary rays coming from the focal spot will be designated as *focal radiation.* The rays falling outside the shadow of the disk included both the primary rays transmitted by the interposed material and the scattered rays.

A lead diaphragm D of 3 inch aperture and 1/16 inch thickness was placed between the scattering material and the film. This enabled six separate exposures to be made from an 8 x 10 inch sheet of film. The area of material rayed could be limited by a cone or diaphragm placed between the tube and the material.

The experimental procedure was as follows: Keeping the tube voltage and current constant, a series of six exposures was made on a sheet of film, producing on development a series of densities varying from light to moderately heavy. Figure 2 shows a series of exposures made in this way. Each exposed portion of the film consisted of a darkened area surrounding a small circular area of lighter density; the density in the small area was caused by diffuse radiation alone, while the density of the outer area was produced by the total radiation transmitted by scattering material. These densities were measured with a photometer, and curves plotted of density against time of exposure, both for the total radiation reaching the film and the diffuse radiation. From these curves were determined the relative exposures required to produce equal densities by the diffuse radiation and by the total radiation; the relative intensity of diffuse and total radiation was taken at the reciprocal of the ratio of exposures required to produce equal density on the film. For in-

stance, if twenty second's exposure to the total radiation produced a given density and twice that exposure, or forty seconds, was required by the diffuse radiation to give the same density, then the diffuse radiation was half the intensity of the total radiation; in other words, half the radiation reaching the film in this case was diffuse, non-image-forming, radiation.

The value obtained is independent of the contrast or degree of development of the photographic material, provided the characteristics of the material are the same for two radiations being compared. In these experiments no definite difference was observed between the characteristic curves produced by the diffuse radiation and the total radiation.

For most of the work ordinary tap water was used as the scattering material. The density of water and its absorption and scattering characteristics are similar to those of human flesh, making it a very suitable material for the present experiments. The water was contained in an aluminum tank 12 inches square by 10 inches deep. The bottom of the tank was 1/32 inch thick. As will be shown later, the absorption of this thickness of aluminum was too small to affect the results appreciably. Some experiments on scattering were also performed with printer's roller composition, a compound made of organic substances and having a density (ratio of mass to volume) of 1.33. This material is more convenient to handle than water, but its scattering power is somewhat too high to be comparable with human flesh.

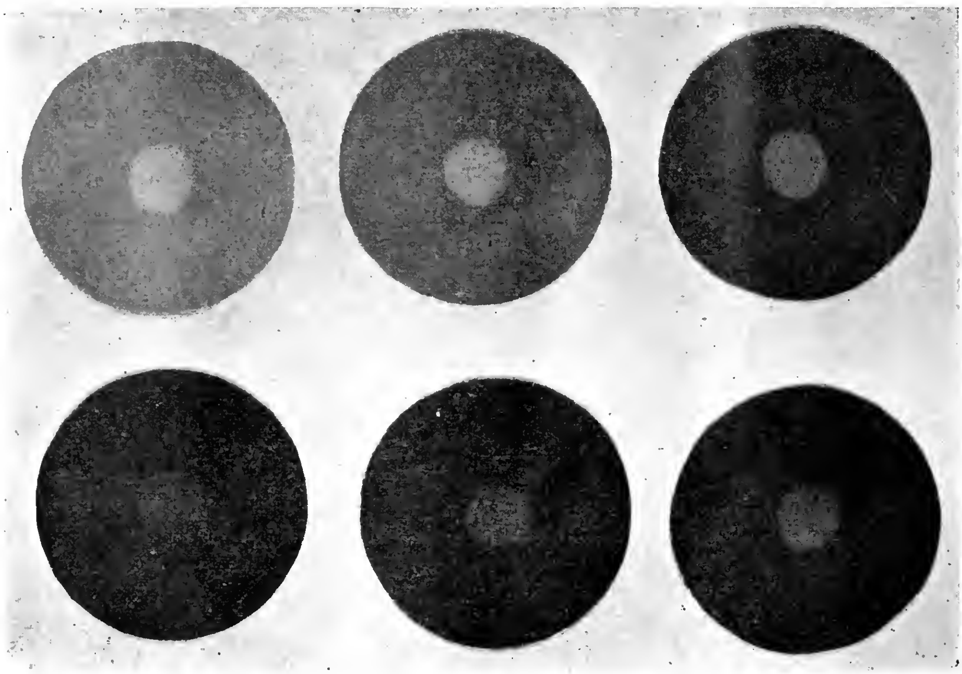

Fig. 2. Illustrating a series of exposures made to determine the ratio of diffuse to total radiation. The lighter density in the center of each exposure was produced by purely diffuse radiation in the shadow of the lead disk; the outer density was produced by the total radiation transmitted by the scattering material.

The spark-gap was measured between dull points, and the tube voltage kept constant during an exposure with the aid of a voltmeter on the primary of the transformer. The Coolidge radiator type tube was used throughout these experiments. The target-film distance was maintained at 20 inches. The tube current was kept constant during each exposure and was adjusted as far as

possible so that the desired densities could be obtained in exposure times varying from ten seconds upward. For long exposures the tube current was not allowed to exceed 4.5 milliamperes. Duplitized x-ray film was used as the photographic material; the films were developed in a tank of elon-hydroquinone developer for five minutes at a temperature approximately 65° Fahrenheit; the films were kept in constant irregular motion to insure uniformity of development[2]. As stated previously, the degree of development of the film has no effect upon the values obtained; the chief consideration is that each film receive uniform development over its whole surface. For each set of conditions six or more films were exposed (unless otherwise specified) and the average value obtained of the ratio of the diffuse to the total radiation reaching the film. The effects of diaphragms, thickness of scattering material, tube-voltage and filters (between the scattering material and film) upon the ratio were investigated.

Figure 3 shows examples of the curves obtained of density plotted against exposure time. The film giving these curves was exposed through six inches of water with the tube running at 5 inch spark-gap and 3.5 milliamperes. The exposures varied from 10 to 40 seconds. The densities of Curve 1 were produced by the total radiation reaching the film, while the densities of Curve 2 were produced by the purely diffuse radiation falling in the shadow of the lead disk. If there were no diffuse radiation, Curve 2 would coincide with the dotted line F representing the fog density, or the density of the unexposed portions of the film. It will be noted, however, that the densities from diffuse radiation are not much less than those produced by the total radiation. At several density values the corresponding exposure times for diffuse and total radiation were read from the curves and their inverse ratios calculated as shown in Table I. The average of these ratios gave the value determined from this film, and the final average was taken from six or more such films. From these particular curves the value of this ratio is .84; in other words under these conditions 84 per cent of the total radiation striking the film is diffuse radiation and 16

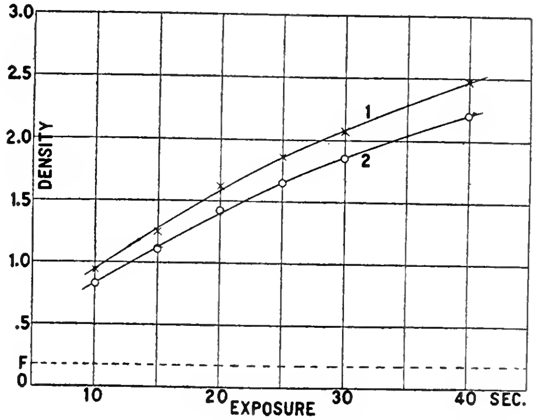

FIG. 3. Curves of density of film plotted against exposure time. Curve 1 is for the total radiation reaching the film, and Curve 2 the diffuse radiation in the shadow of the lead disk. Conditions; 6 inch depth of water (12 x 12 inches) as the scattering material, 20 inch target-film distance, 5 inch spark-gap, 3.5 milliamperes. F represents the fog density, or the density of the unexposed portions of the film.

TABLE I

DATA TAKEN FROM CURVES OF FIGURE 3

Density of Film	*Exposure to Total Radiation in Seconds* E_T	*Exposure to Diffuse Radiation in Seconds* E_D	*Ratio of Exposures* $\frac{E_T}{E_D} = \frac{D}{T}$
1.0	10.7	12.8	.84
1.3	15.4	18.2	.85
1.6	20.2	23.9	.84
1.9	25.9	31.3	.83
2.2	33.2	40.4	.82
		Mean	.84

[2]This precaution is unnecessary in developing ordinary radiographs.

per cent is image-forming or focal radiation.[3]

The proportion of diffuse radiation reaching the film was first investigated for various thicknesses of water and different sizes of cones or diaphragms[4] with the tube running at a 5 inch spark-gap. The results are arranged in Table II.

as long as the image diameter on the film is kept the same. Therefore with a constant target-film distance of 20 inches, it is unnecessary to describe the cone or diaphragm otherwise than to give the image diameter produced by it. The smaller image sizes were produced by small lead diaphragms supported at the surface of the water, and the

TABLE II

Thickness of Water in Inches	*Diameter of Image in Inches*	*Ratio Diffuse to Total Radiation Observed*	*Ratio Diffuse to Total Radiation from Curves* $\frac{D}{T}$	*Ratio Scattered to Total Radiation* $\frac{S}{T}$	*Exposure Factor*	*Ratio Diffuse to Primary Focal Radiation* $\frac{D}{F}$
	.56	.12	.12	.08	1.8	.14
	1.30	.25	.23	.20	1.5	.30
2	4.0	.43	.43	.41	1.14	.75
	6.25	.50	.50	.48	1.0	1.0
	20.0	.50	.50	.48	1.0	1.0
	.62	.15	.15	.12	3.0	.18
	1.47	.33	.33	.31	2.4	.49
4	4.0	.57	.57	.56	1.5	1.33
	6.25	.68	.68	.67	1.14	2.1
	20.0	.72	.72	.71	1.0	2.6
	.71	.18	.18	.16	4.9	.22
	1.68	.40	.42	.41	3.5	.72
6	4.0	.64	.65	.64	2.1	1.9
	6.25	.77	.77	.76	1.4	3.3
	20.0	.83	.83	.83	1.0	4.9
	.83	.22	.22	.20	6.7	.28
	1.96	.52	.51	.50	4.2	1.04
8	4.0	.72	.72	.71	2.4	2.6
	6.25	.81	.81	.81	1.6	4.3
	20.0	.87	.88	.88	1.00	7.3
	4.0	.76	.76	.76	3.0	3.2
10	6.56	.83	.83	.83	2.1	4.9
	20.0	.92	.92	.92	1.0	11.5

The first column gives the thickness of water x-rayed. The second column gives the diameter of image on the film as determined by the cone or diaphragm used between the tube and the scattering material; this value suffices for the specification of the cone or diaphragm. The dimensions and position of the cone or diaphragm between the tube and the scattering material make no difference

[3]The final average for all the films exposed under these conditions was 83%, as shown in Table II.

[4]The efficiency of the Bucky diaphragm principle was not determined in the present experiments, but will be investigated in the near future.

corresponding image diameters vary with the thickness of water; the larger sizes were made with cones, and the largest size, 20 inches, was that produced by the opening in lead glass shield around the tube.

The image diameters given have been corrected for the area of the shadow of the small lead disk. In the case of the smallest image size (made with a ½ inch diaphragm) the lead disk was not used; the ratio of diffuse to total radiation was determined by measurements of the densities on the film of the image of the diaphragm opening and

the densities (from diffuse radiation) just outside the diaphragmed image.

The third column gives the observed ratios of the diffuse to the total radiation. When these are plotted against thickness of water, a number of the values do not fall on a smooth curve. For the succeeding calculations, values taken from the curves were taken as the most probable values and are tabulated in column 4. The scattered radiation is somewhat less than the diffuse radiation, since the latter includes primary radiation from other parts of the target than the focal spot. The small correction for this deducted from the values of column 4 give the ratios of scattered to total radiation as tabulated in column 5. The method of making this correction is described later.

When scattered radiation is lessened by means of a cone or diaphragm, the decreased intensity of the radiation striking the film necessitates a longer exposure. For each thickness of water, the exposure for a 20 inch image is here taken as the ordinary or standard exposure. The factor by which this exposure must be multiplied to produce the same density of film when a cone or diaphragm further limits the scattered radiation is called the "exposure factor"; these factors are calculated from the values of column 5 and are tabulated in column 6. This calculation is based on the fact that the intensity of primary radiation reaching the film is unaffected by the cone or diaphragm; only the scattered radiation is thereby diminished. Let P_{20} represent the primary radiation, S_{20} the scattered radiation, and T_{20} the total radiation reaching the film with an image diameter of 20 inches, and P_X the primary radiation, S_X the scattered radiation, and T_X the total radiation reaching the film where the image diameter is X inches. If the total x-ray intensity reaching the film is diminished in the ratio of $\frac{T_X}{T_{20}}$ the exposure time must be multiplied by the inverse ratio in order to obtain the same density of film; the exposure factor is therefore $\frac{T_{20}}{T_X}$

Now, $T = P + S$, or $P = T - S$
and $P_X = P_{20}$
Then,

$$\frac{T_{20}}{T_X} = \frac{\frac{T_{20}}{P_{20}}}{\frac{T_X}{P_X}} = \frac{\frac{T_{20}}{T_{20} - S_{20}}}{\frac{T_X}{T_X - S_X}} = \frac{1 - \frac{S_X}{T_X}}{1 - \frac{S_{20}}{T_{20}}}$$

By this equation the exposure factors may be computed from the values of $\frac{S}{T}$ tabulated in column 5.

The number which is the true measure of the effect of the diffuse radiation is the ratio of the diffuse radiation to the primary focal radiation. This ration is given in the last column; it is computed by the relation $\frac{D}{F} = \frac{\frac{D}{T}}{1 - \frac{D}{T}}$ where $\frac{D}{F}$ represents the ratio of diffuse to focal radiation, and $\frac{D}{T}$ the ratio of diffuse to total radiation, the values of which are tabulated in column 4. For instance, if the ratio of diffuse to total radiation is .80, the ratio of focal to total radiation is 1 —.80 or .20 and the ratio of diffuse to focal radiation is $\frac{.80}{.20}$ or 4.0.

The values in Table II show the large part played by scattered x-rays in the radiography of the thicker parts of the human body. Under most conditions the diffuse radiation is by far the major portion of the radiation reaching the photographic surface; under conditions similar to those in the radiography of deep parts the intensity of the diffuse radiation is about 4 to 10 times the intensity of the focal radiation. Its marked effect in reducing contrast and definition can readily be appreciated. The elimination of all or a large part of the diffuse radiation should result in a great improvement in the quality and diagnostic value of radiographs. Diffuse radiation is reduced to a relatively small value by diaphragming the image to a very small size, ¾ inch in diameter or less.

This size is too small to be of much use although it might be of occasional value in such work as studying the fine structure of diseased bone tissue.

Figure 4 shows the curves of ratio of diffuse to total radiation plotted against thickness of water (for the various sizes of cones and diaphragms). The observed values are indicated by small circles. Figure 5 gives the curves of ratio of diffuse to focal radiation plotted against thickness of water, showing the increase of the scattering effect with increase in thickness of water. Figure 6 shows this ratio plotted against image diameter for the various thicknesses of water; the number on each curve represents the thickness of water in inches. This set of curves is the most instructive of any of those shown. For each thickness of water, as the image diameter is diminished from 20 inches, the scattering does not much decrease until a certain point is reached; then as the image size is further diminished the scattering decreases quite rapidly. This effect is most noticeable for the smaller thicknesses. In radiographing through 2 inches of water, no decrease in scattering is produced by diaphragming the image to 6¼ inches diameter. The image size where the scattering begins to diminish appreciably is greater for the greater thicknesses of water. In radiographing through 10 inches of water, diaphragming to anything less than 20 inches produces a marked decrease in the scattering effect. The ordinate value unity represents a diffuse radiation of one-half the intensity of the total radiation. The portions of the curves above this value show the large range of conditions where the diffuse rays form the greater portion of the total radiation reaching the film. It is evident that in using a cone or diaphragm to reduce scattered radiation, the smallest size practicable under the circumstances should be employed.

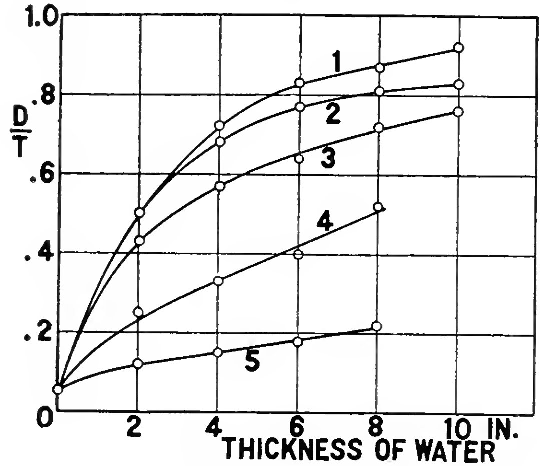

Fig. 4. Curves showing ratio of diffuse to total radiation plotted against thickness of water. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter of 6.25 inches; Curve 3, image diameter of 4 inches; Curve 4, a diaphragm of 1 3/16 inch diameter at surface of water; Curve 5, a diaphragm of ½ inch in diameter at surface of water.

In order to derive the ratios of scattered to total radiation from the ratios of diffuse to total radiation measured experimentally, it was necessary to determine the proportion of primary radiation reaching the film from other parts of the target than the focal spot.

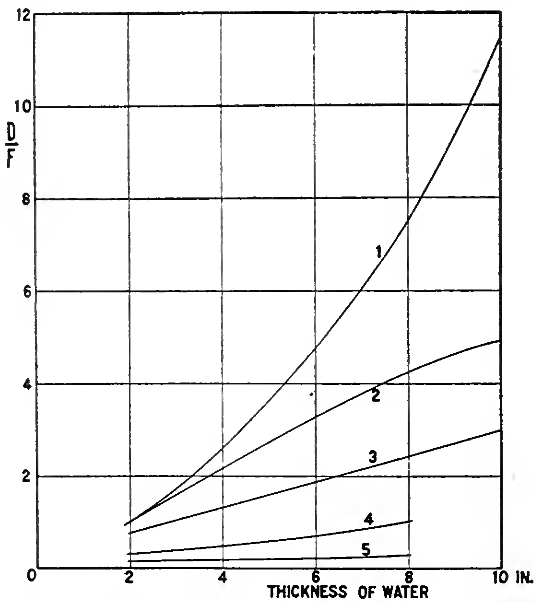

Fig. 5. Curves showing ratio of diffuse to focal radiation plotted against thickness of water. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter 6¼ inches; Curve 3, image diameter 4 inches, Curve 4, 1 3/16 inch diaphragm at surface of water; Curve 5, ½ inch diaphragm at surface of water.

If in the arrangement shown in Figure 1

the scattering material be omitted, the radiation falling in the shadow of the small lead disk is extra-focal primary radiation. Its ratio to the total radiation was measured by the method already outlined. i. e., by determining the relative exposures required for equal densities of film in the shadow of the

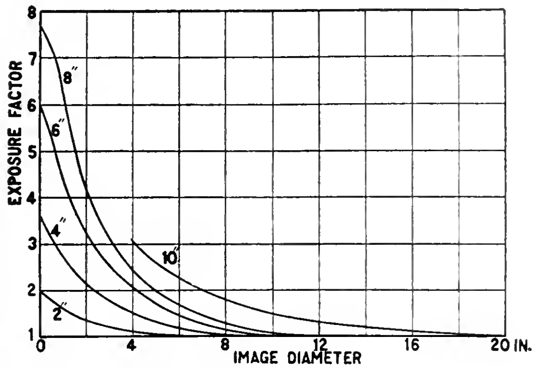

Fig. 6. Curves showing ratio of diffuse to focal radiation plotted against image diameter. The thickness of water is designated on each curve.

lead disk and just outside that shadow. By this method, with no absorbing material between the tube and the film, the radiation from other parts of the target than the focal spot was found to be .053 of the total radiation. This value was found to be about the same for all sizes of cones or diaphragms and for all positions of the small lead disk used in the present experiments. Since the effect of the extra-focal radiation upon the ratios $\frac{D}{T}$ of column 4, Table II, is very small, its precise determination for every set of conditions is unnecessary. The greatest variation in the proportion of extra-focal radiation was produced by the absorbing material between the target and the film. The radiation from the copper of the target is softer than that from the tungsten, and it is therefore absorbed more when matter is introduced between the target and the film. The proportion of extra-focal primary radiation reaching the film when scattering material was inteposed was determined by measuring the relative intensities of radiation reaching the film with the target face turned toward the film and with the target face turned away from the film. By this method with no absorbing material present, the radiation from the back of the target was found to be .041 of the radiation from front of the target. With 4 inches of water this was reduced to .026 or 63 per cent of the value for no absorbing material. With 6 inches of water this ratio was found to be .020 or 49 per cent of the value for no absorbing material. The proportion of extra-focal radiation when the target face is turned toward the film had been found to be .053 with no absorbing material. With 4 inches of water this value should be reduced to 63 per cent of .053 or .033. With 6 inches of water this value becomes 49 per cent of .053 or .026. The determinations for greater thicknesses of water required such long exposures that it was decided not to make them, but rather to use in the computations values extrapolated from the curve of the already observed values. The curve of the ratio of extra-focal primary radiation to total primary radiation reaching the film, plotted against thickness of water, is shown in Figure 7.

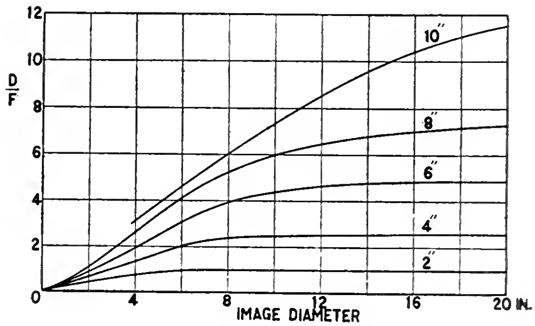

Fig. 7. Curve showing ratio of extra-focal primary radiation to total primary radiation plotted against thickness of water.

It was now required to determine the effect of the extra-focal radiation upon the ratio of diffuse to total radiation. Let P represent the total intensity of the primary radiation reaching the film when a given amount of scattering material is interposed. Let a be the fraction of this coming from other parts of the target than the focal spot;

then aP is the intensity of the extra-focal primary radiation and $(1-a)$ P the intensity of the focal radiation. Let S be the scattered radiation, D the total diffuse radiation, and T the total radiation, reaching the film.

Then $D = S + aP$, (1)

and $T = S + P$; (2)

also $T = D + (1 - a)P$ (3)

Dividing equation (1) by T, we find that the observed ratio of diffuse to total radiation

$$\frac{D}{T} = \frac{S + aP}{T} \quad (4)$$

Substituting for P its value T — S by equation (2), we obtain

$$\frac{D}{T} = \frac{S + aT - aS}{T} = \frac{S(1-a) + aT}{T}$$

$$= \frac{S(1-a) + a}{T} \quad (5)$$

Whence

$$\frac{S}{T} = \frac{\frac{D}{T} - a}{1 - a} \quad (6)$$

Thus by this equation the ratio of scattered to total radiation, $\frac{S}{T}$ may be computed from the experimentally determined value of the ratio of diffuse to total radiation, $\frac{D}{T}$. For example, the value of $\frac{D}{T}$ for 4 inches of water and 6.25 inch image diameter is .68 (Column 4, Table II), and the fraction a has the value .033. Then applying equation (6)

$$\frac{S}{T} = \frac{1 - .033}{.68 - .033} = \frac{.647}{.967} = .67$$

the value recorded in Column 5, Table II.

The values of $\frac{S}{T}$ are required for the calculations of the exposure factors. It will be noted that in the presence of any considerable amount of scattered radiation, the difference between $\frac{D}{T}$ and $\frac{S}{T}$ is quite small, usually about .01 or .02; under such conditions the extra-focal primary radiation is a negligible portion of the total radiation reaching the film, and it is quite small (5 per cent or less) when there is no scattered radiation.

The curves in Figure 8 show the variations of exposure factor with image diameter; the thicknesses of water are indicated by the numbers on the curves. The exposure factors for zero image size are the values computed for the case where all the diffuse radiation is removed.

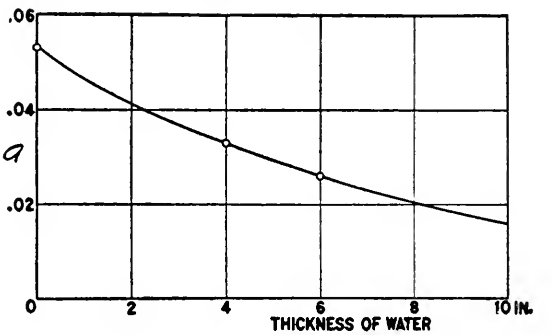

FIG. 8. Curves of exposure factor plotted against image diameter. The thickness of water is designated on each curve.

It may be noted in this connection that the efficiency of a diaphragm under any

TABLE III

Thickness of Composition in Inches	*Diameter of Image in Inches*	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
2	1.30	.30	.43
	4.0	.47	.89
	20.0	.55	1.22
4	1.47	.35	.54
	4.0	.66	1.9
	20.0	.76	3.2
6	1.68	.46	.85
	4.0	.73	2.7
	20.0	.88	7.3

conditions can be estimated roughly from the exposure factor. For instance, if a given diaphragm necessitates a doubling of the exposure to produce the same density, the total x-ray intensity has been halved and more than half of the diffuse radiation has been removed.

With printers' roller composition as the scattering material, the results recorded in Table III were obtained. Most of these values are the mean of three or four determinations and are therefore not quite so reliable as the results obtained with water. For equal thicknesses, the printers' roller composition scatters more than water; the proportion of diffuse radiation reaching the film is roughly the same for equal masses of water and roller composition rayed, i. e., for equal image sizes, a given thickness of roller composition produces about the same proportlon of scattered radiation on the film as a one-third greater thickness of water (density of composition being 1.33).

The effect of tube voltage upon the proportion of diffuse radiation striking the film was studied for a range of spark-gaps from 3 to 9 inches, radiographing through a thickness of 6 inches of water. Table IV shows a summary of the results obtained. The effect of scattered rays upon the film was found to increase slowly with the spark gap. Thus the lowering of contrast produced by increasing the penetration is due in part to the increased scattering as well as the lowered absorption of the image-forming rays.

These data indicate that the scattered radiation affecting the film is slightly harder than the primary radiation, since an increase in the proportion of hard rays in the primary beam increases the proportion of scattered rays reaching the film. This is to be expected from the fact that the scattered rays have traversed a longer distance in the material than the primary rays, and have suffered a corresponding greater filtering action; the soft scattered rays have been thereby absorbed more than the soft primary rays before reaching the film, leaving a greater proportion of hard rays in the scattered radiation.

Contrary to this conclusion, it is sometimes claimed that the so-called "soft secondary radiation" can be screened out by

TABLE IV

EFFECT OF TUBE VOLTAGE UPON PROPORTION OF DIFFUSE RADIATION IN RADIOGRAPHING THROUGH SIX INCHES OF WATER

Spark Gap in Inches	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
3	.81	4.3
4	.82	4.6
5	.83	4.9
5½	.85	5.7
6	.85	5.7
7	.85	5.7
9	.87	6.7

TABLE V

Filter	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Primary Focal Radiation*
None	.83	4.9
1/16 inch aluminum	.82	4.6
1/8 inch aluminum	.80	4.0
.001 inch lead foil	.79	3.8
Thin intensifying screen	.79	3.8

a filter placed between the subject and the plate, with the effect of noticeably improving contrast in the radiograph. This view is evidently due to an impression that the secondary radiation from the human body is largely fluorescent radiation. To test out this point, the proportions of diffuse radiation affecting the film were determined with several types of filters placed between the scattering material and the film, with the tube running at a 5 inch spark-gap. Table V gives the results obtained in radiographing through six inches of water. The filters specified are in addition to the 1/32 inch of aluminum of the bottom of the tank. This thickness of aluminum evidently has some slight influence upon the scattered rays, but its effect is certainly less than the errors of observation. For present purposes, it may be considered part of the scattering material. The various filters are seen to diminish slightly the effect of scattered radiation upon the film; the action of the lead foil and the intensifying screen filters is slightly greater than that for aluminum. The effect of the filters may perhaps be ascribed to the fact that scattered rays making small angles with the film must traverse a greater thickness of filter. While a filter may tend to increase contrast slightly by reducing the proportion of scattered rays, its action in filtering out the softer primary rays tends to reduce the contrast. An experiment to determine the effect upon contrast of a lead foil filter between the scattering material and the film showed that the filter produced no change in the contrast.

SUMMARY

The relative photographic intensities of diffuse and primary focal radiation reaching the film were measured under a variety of conditions, showing the effects of thickness of scattering material, sizes of cones or diaphragms between the tube and the scattering material, tube voltage, and filters placed between the scattering material and the film.

Under conditions similar to those in the radiography of thick parts, the scattered radiation reaching the film is roughly from four to ten times the intensity of the primary focal radiation. The intensity of the scattered radiation is small when the thickness of the scattering material is small or when the x-ray image is diaphragmed to a very small size. Data on the effects of thickness of scattering material and image size are given in Table II, and are shown graphically in Figures 4, 5, and 6.

The removal of any scattered radiation necessitates an increase in exposure, to compensate for the loss in total x-ray intensity. The exposure factors corresponding to the various thicknesses of water and image sizes are given in Column 6 of Table II, and are shown graphically in Figure 8.

The ratio of diffuse to primary radiation reaching the film was found to increase slightly as the tube voltage was increased.

Filters placed between the scattering material and the film diminish slightly the proportion of diffuse radiation; the filters are of no practical value, however, inasmuch as they do not improve radiographic contrast.

REMARKS ON THE MEASUREMENTS OF SCATTERED RADIATION

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THE application of roentgenology of the figures in Mr. Wilsey's paper on scattered x-rays promises most valuable results, for the writer believes that this is one of the faw contributions of quantitative measurements of scattered x-rays that can be directly applied in practical work.

A number of physicists—Barkla, Hull and

others— have derived physical laws governing the absorption and scattering of x-rays by matter, but such figures are exceedingly difficult to apply in roentgenology. Mr. Wilsey's results, on the other hand, may be applied to such problems as radiography and therapy, for the empirical formulae derived contain only those factors that exist in these phases of x-ray science. For example, not only can it be seen that, as the diphragm aperture is reduced, the volume of scattered radiation reaching the film is reduced, but the proportional reduction of scatter may be computed directly and the necessary change in exposure time compensated for.

To illustrate: A kidney negative is taken at 25 inches target-film distance, using a diaphragm that covers a 20 inch circle at the film. Let us assume that eight inches of tissue are passed through. The result is a gray, foggy negative with very little detail, for the effect of the image-forming rays has been neutralized by the general fog produced by the scattered rays.

A study of Mr. Wilsey's charts shows that under such conditions the scattered radiation reaching the film has a value equal to 88 per cent of the effective radiation striking it. That is, only 12 per cent of the exposure is image-forming—the rest is obscuring detail.

Substituting a diaphragm that reduces the circle of illumination to 4 inches in diameter, we see that the effect is to reduce the scattered radiation from 88 to 71 per cent, with a proportional increase in the effectiveness of the image-forming rays.

The increase in exposure time necessary to compensate for the loss in total radiation is also given in the tables. For this theoretical case it is necessary to multiply the exposure by 2.4.

It is well this latter fact in mind in work with the Potter-Bucky diaphragm, for the reduction in scattered radiation is analogous to the foregoing. In the average type of Potter-Bucky diaphragm on the market at present the time factor is about 3 or 4. In fact, unless such a diaphragm does have a factor of this order, it would be of very low efficiency, for it would mean that there was very little reduction in the volume of scattered radiation striking the film.

This time increase makes it desirable in a great many cases to use intensifying screens, and Mr. Wilsey's data on the most effective use of these should be studied.

The method used in the paper in question offers a simple means of testing other methods of diaphragming, for all the apparatus necessary is a small cylinder of lead and dental films; at least for a qualitative estimate.

It seems that further applications of these results should be in the field of therapy, for here, obviously, the important thing to know is how much radiation is reaching each cubic centimeter of tissue, and it is evident that this may be computed, at least approximately, from the figures given; certainly with more accuracy than assuming a straight logarithmic absorption law or attempting to deduce from physical measurements of absorption coefficients.

In all such applications it should be borne in mind, however, that the improvement in quality of the image obtained is of such an order of magnitude that errors in technique, especially in the dark room in the case of making negatives, might easily obscure it; therefore the more urgent is the need of standardization in technique, for obviously it would be of little use to remove an obscuring fog by diaphragming and later introduce as dense a fog or a heavier by improper development.

THE BUCKY DIAPHRAGM*

By H. W. VAN ALLEN, M.D.

SPRINGFIELD, MASSACHUSETTS

ONE of the most successful roentgenologists recently said that the moving Bucky diaphragm is the greatest advance in our science since the advent of the Coolidge tube. Great credit is to be given to Dr. Hollis Potter of Chicago for the development of the present status of the method of application of the idea introduced by Bucky of Germany. The original diaphragm produced a radiograph covered by lines running in both directions, the result appearing as though viewed through a grating, and was not a practical procedure. Dr. Potter's method of moving the grid during the exposure has given us a radiograph that is not only practical in its results but startling in its efficiency.

The few moments I shall speak to you I will divide in three portions:

First. A description of the principles of the diaphragm;

Second. The mechanical devices that aid in making a diaphragm satisfactory, and

Third. Some points in the use of the instrument that have been of aid to me.

I presume most of you know the principles involved in the Bucky diaphragm, but I am equally certain a few do not, so I will ask those in the first class to bear with me during a brief description.

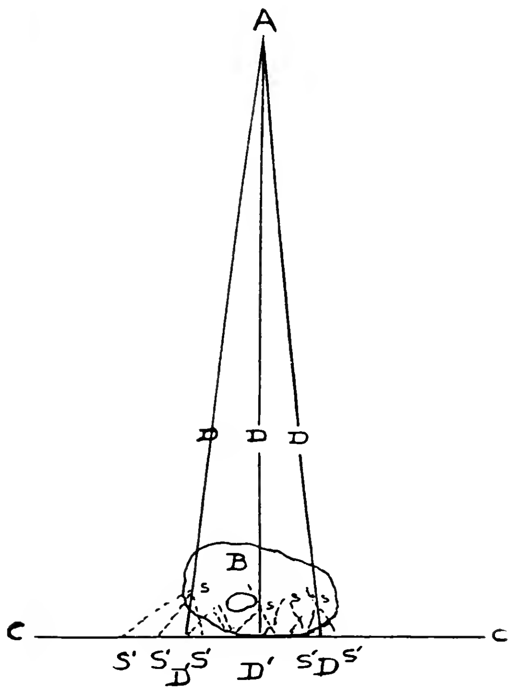
When the roentgen ray is passed through resisting substances, secondary rays are given off by this substance. These rays go in all directions. Their excursion is short, but they come from all directions and are more in quantity than the primary ray. These are the rays that fog our plate, making them hazy through the thicker parts of the body, and produce a limit to our ability to examine successfully very large persons. The whole purpose of the Bucky diaphragm is to cut off or strain out as it were the major part of these rays and leave the direct rays unchanged. Probably I can illustrate this in the quickest manner by demonstrating with two charts similar to those published by several authors.

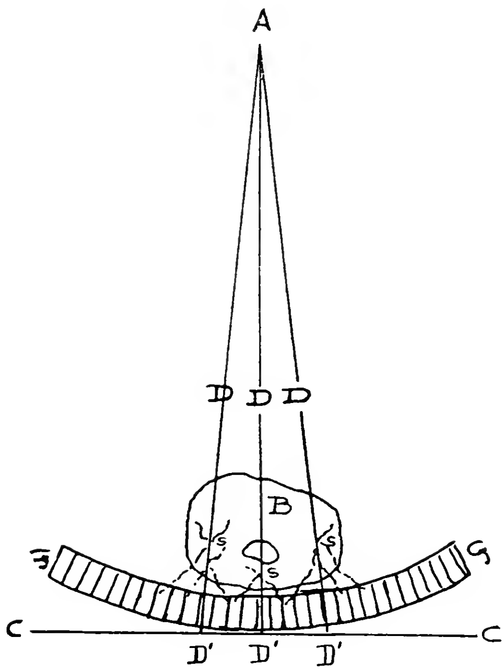
The whole function of the apparatus is to prevent the secondary or fogging rays from striking the plate. Their angle is such that they cannot pass down through the narrow spaces between the lead strips, but striking the lead are prevented from reaching the plate, while the primary ray meets with no such interference and a plate results practically clear from fog.

As to the mechanical perfection of the diaphragm many things are necessary for success. Naturally, one thinks first of the grid. It must be strong and yet light in weight. This we accomplished by making the frame of huron metal—as strong as steel and as light as aluminum. The wood strips of which the grid itself is made up must withstand weather conditions. All wood swells and shrinks with atmospheric changes. Springs are placed at each end, which keep the slats pressed together under all circumstances. An open question is the placing of the lead strips. We experimented with various models and got the best results with about six strips to the inch of three-quarter inch thickness. When the lead strips are closer together the actual amount of lead becomes a factor in making the exposure longer. It is self-evident that the width of the strips does not retard the ray but only the thickness of the lead, so twice as many strips produce twice as much cutting off of the direct ray. The lead used was one half of one hundredth of an inch in thickness. It is also manifest that the wider the strips the more of the secondary rays are cut off. But after a little another disadvantage comes in; that is, the increasing distance between the patient and the plate. Up to three quarters

*Read at the Midwinter Meeting of the Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 28, 29, 1921.

of an inch there seemed to be no difference; beyond this there came distortion. The lead strips should go entirely through the grid, as any other method only increases the patient-plate distances, which is one of the defects of this method of examination. Hollowing out the strips in the center of the sides makes them pinch only on the edges. The wood strips must be narrower on one edge to insure perfect direction of the lead that position it can be placed at the side of the patient and obtain beautiful radiographs in pneumoperitoneum. Ball-bearing rollers on each side a "V" shaped projection on the grid insure this result. The check to regulate and make the speed uniform is the commonly used principle of a fluid passing through an opening in a piston head. A very satisfactory arrangement was made whereby this valve can be regulated by turning the piston rod.





A = focal point.
B = object to be radiographed.
C = plate.
D = primary ray.
S = secondary ray.

S' = points where the secondary ray strikes the plate.
D' = points where primary ray strikes the plate.
G = grid composed of lead strips supported by intervening wood strips.

strips toward the central point 25 inches away or the focal point of the tube. The motion of the grid must be uniform. We tried several methods and found two springs better than one, as any friction in one was replaced by the action of the other. A grid should move in any position with equal ease. It is important not only to be able to make the exposure with the patient lying on the diaphragm but also with the patient standing and the diaphragm at his back for sacro-iliac joints. Again, if the diaphragm will work in This made necessary only a single rod, projecting from the diaphragm, for setting and regulating the speed. Also it was found that this same valve, by means of a retaining spring, could be used for the return of the fluid, which obviated the necessity of a bypass. The next essentials were placing and holding the plate. This is easy when the diaphragm is flat, but more difficult in the vertical position. Not only this, but the plate must be held in any place under the grid, and for stereoscopic work must be replaced

in exactly the same position again. A removable pan with lugs accomplished this for us.

Many minor things come to one's mind when working with a new instrument of this kind, as a method of centering the tube, a bell for notifying the operator when the motion of the grid is about over, and handles for ease of placing the diaphragm in position. Some method of stabilizing and compressing the patient is of great value, especially in the upright position.

As to some of the practical points in working with this diaphragm, I am most often asked about the time of exposure. A great deal more than 50 per cent of the photo-chemical effect on the radiographic plate is produced by secondary radiation. Therefore the better the Bucky diaphragm the longer will be the exposure to produce a given amount of darkness on the plate. The more secondary or harmful rays that are cut out the more primary rays will be needed. In actual practice however the time of exposure is not greatly lengthened, as with no more fear of the large amount of secondary rays set up by hard primary rays, longer spark-gap becomes a distinct advantage in penetrating the head and torso of large patients. This is particularly true in the case of those of us who have been using short spark-gaps in our work. Those already using long spark, of course, will of necessity increase the time of exposure when using the diaphragm. The larger the patient the harder the ray required and the more secondary rays produced. These are cut off by the diaphragm, so this makes it possible to say, relatively speaking, the larger the patient the better the plate.

When is it best to use a diaphragm? On all thick parts. When, however, we get down to about three inches of flesh the advantages of the diaphragm are offset by the distance of the patient from the plate and it is no longer of use.

Must the tube be just 25 inches from the plate? No, but placing the tube nearer or farther away causes the direct ray to strike the lead strips not exactly on edge but makes the shadow of the strips wider and this increases the obstruction and length of exposure, which in the case of more than 25 inches added to the distant effect multiplies rapidly. The upright position becomes very valuable in showing ptosis of organs, as the stomach, kidney, etc.; also luxation of the sacro-iliac joint and fifth lumbar vertebra. Side-to-side plates become of value when taken with the added clearness obtained by this method.

A very practical caution I wish to call to your attention is the danger of a burn. These patients are usually large. Were it not for the 25 inches required by the grid one would naturally increase the distance. By not doing so the skin target is quite short. Some defect in the technique may have caused you to get a corresponding defect in the plate. Care must be used not to get an erythema skin dose by repeated exposures.

The grid must be in motion during the entire exposure; the least variation from this rule will give undesirable lines. If for any reason it seems desirable several excursions of the grid may be made for a single radiograph.

I have of late been using a curved cassette with considerable advantage. The curve is the same as that of the grid. In this way all parts of the film are equally distanced from the focal spot and receive equal energy. Each ray strikes the plate at right angles and consequently there is no distortion, and the fuzzy appearance, so common in objects distant from the plate, is obviated. It is also evident that a film curved in this way will cover more of the cone of rays coming from the focal spot than the same plate straight at the distance of the center of the cone.

In conclusion I submit that the Potter-Bucky diaphragm has come to stay as a great aid to roentgenologists. Its final form may be quite different, but the principle is permanent.

SOME ACCESSORIES TO THE POTTER-BUCKY DIAPHRAGM

By DAVID RALPH BOWEN, M.D.

Roentgenologist, Pennsylvania Hospital

PHILADELPHIA, PENNSYLVANIA

ESTIMATES of the value of the Potter-Bucky diaphragm as an advance in roentgenography will, doubtless, vary considerably among roentgenologists. But among those who have mastered its technique, we are sure these estimates will all be high. It is hardly conceivable, for the present, that one who has learned to use this device successfully will be content to do without it.

There are, however, serious practical objections to the apparatus as at present delivered by the various makers. The equipment used by Dr. Potter, in which the diaphragm is adjustable under a canvas stretcher on which the patient reclines, is ideal; but very few have the discarded apparatus which Dr. Potter utilized in his office, and to construct such an apparatus *de novo* entails an expense which many will wish to avoid.

The apparatus here described has proven practical. It obviates all necessity of handling the heavy and somewhat unwieldy apparatus and since we have had it we notice an inclination to increase, rather than decrease, the number of cases in which we use it.

It consists primarily of a simple wooden table constructed at the Pennsylvania Hospital by the house carpenter. The top of the table is made to conform to the curve of the diaphragm, from which it extends two feet on one end and three feet on the other, making a table practically seven feet long, with a recess into which the diaphragm sets so as to be flush with this curved top. In use, a folded bed-sheet is always laid lengthwise of of the entire table and upon this the patient is placed. Even with patients weighing two hundred pounds and over it is not difficult to shift them lengthwise of the table to any desired point by pulling on one or the other end of the sheet. If the top of the table is properly polished this maneuver will be found surprisingly easy; and it is believed that the centering can actually be done in less time than by any of the various mechanisms which might be suggested for the purpose.

Having proceeded this far it becomes desirable to center the tube over the diaphragm after the patient is in place. This is accomplished by a device which we may call a bridge, illustrated in the cut at A. By appropriate marks on either side of the diaphragm, this bridge is readily placed so that a hole

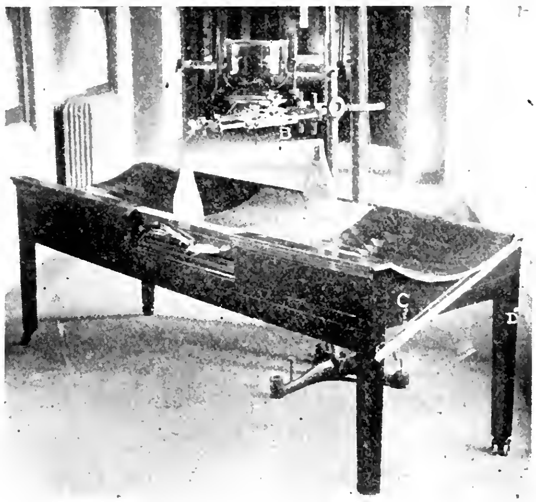


Fig. 1. Showing table described with the diaphragm, bridge and tube in position.

through the top of it is directly perpendicular to the top of the diaphragm, and twelve inches above it. By means of a plumb-bob, illustrated at B and elsewhere described[1], the focus spot of the tube is centered directly over this mark on the bridge and thirteen inches above it. If a single exposure is to be made, the tube-stand is fastened at this point and both the bridge and plumb-bob are removed. Stereoscopic exposures are accomplished by dividing the stereoscopic shift,

[1] *Am. J. Roentgenol.*, February, 1918, V, 60.

half toward the head and half toward the feet, from this center point. (Because of difficulty in lighting, a tube-stand has been used in the accompanying illustration which does not permit shifting in this direction.)

It is vitally important, in using this diaphragm, that the operator should know, all the time, just what proportion of the excursion of the diaphragm has been accomplished. A bell which rings near the end of the exposure is of doubtful utility and frequently disturbs the patient, when such disturbance is least desired. We have adopted a signal device, illustrated at C, one end of which is connected by a cord with the moving member of the diaphragm. During the excursion, the end of this pointer travels from the high point at which it is illustrated to the white spot at D. This arrangement permits constant visibility of the excursion in the position in which we work. It could, of course, be arranged at either end or even above the table.

These suggestions are offered as having greatly increased our efficiency in the use of this instrument and as, perhaps, being adaptable by variations to many other laboratories. Dr. Manges has, for instance, found it possible at the Jefferson Hospital to have both table and tube-stand in a fixed position, so that it is necessary only to center the patient on the table.

Perhaps no one factor has caused so much disappointment in the use of the Potter-Bucky diaphragm as the lack of contact of the film with double intensifying screens. We have found that a set of six wooden wedges, forced under the ends of the three springs on the back of the cassette, has almost eliminated this trouble. Such a proceedure is crude, of course, but, pending the time when cassettes which really force contact between film and screen over the entire surface are obtainable, we believe that this maneuver will more than repay the little extra effort which it entails.

DISCUSSION OF DR. J. H. ULLMANN'S PAPER

"Practical Application of the Sphere Gap to Roentgenotherapy"

(Published in the April Issue)

Dr. J. G. Van Zwaluwenburg. I should like to ask Dr. Ullmann if the error does not become progressively greater as you increase the filtration, and whether minor differences in penetration do not produce disproportionately large fluctuations in the quantity of the emergent ray, because of the relatively greater absorption of the softer ray compared with the harder ray. This might have a very important influence in our determination of the standard erythema dose for the individual machine and "set up."

Dr. Hollis E. Potter. First, Dr. Ullmann has shown that there is a discrepancy between supposed and actual voltage of as high as 35 or 40 per cent. This discrepancy is enough to account for the difference between burns and under-dosage.

Second, peak voltage is one of the most important factors in determining the dosage, since it is one of the two factors that vary according to the square.

It is accepted among engineers that the sphere gap is the one best way to measure the voltage of high tension currents, and it is about the only way to standardize a given machine so that it can be made to duplicate results obtained on other apparatus.

It is to be hoped that the manufacturers of apparatus to be used in therapy will provide suitable sets of sphere gaps that can be used by therapists. It is not for routine readings for the occasional verification of their voltmeters.

Dr. H. J. Ullmann. I spoke of using 6.25 or 12.50 cm. spheres because one can get tables showing breakdown voltage for these sizes. I used a 12.50 cm. sphere for this work (12.50 cm. is about 5 inches) as it is the most convenient size for the range of voltage that we have to measure. My apparatus will go to

about 180 kilovolts effective before it reaches the limit of the dimensions laid down as a standard.

For accurate work the longest gap should not be greater than the diameter of the spheres but in practice a gap not more than three times the radius may be used. The sphere diameter should not vary more than 00.1 per cent. or the curvature more than 1 per cent from a true sphere. The spheres should be at least twice the gap setting from surroundings and the shanks not greater than one-fifth the sphere diameter.

In regard to filtration I have some figures here based on the work of Dr. Hall of Schenectady, published in the *Proceedings American Institute Electrical Engineers*. Approximately 50 per cent of all the rays passing through 5 mm. of aluminum at 90 KV effective are of the very hard order and at 80 KV the proportion is 4 per cent lower, i. e., 46 per cent. Also according to Dr. Hall's curve if the volume of ray of about 0.2 angström in length is 60 at 80 KV, it will be 100 at 90.

In regard to the question of motors in direct current machines these tests, with one exception, were all made on alternating current outfits. There is no variation in voltage readings at different cycles within the commercial range. I do not know if the readings would be affected by variations above or below these.

I would like to ask Mr. Darnell to tell us if there would be a variation under conditions liable to be met with in our work.

Mr. Darnell. I am not sure; it depends upon circumstances. It is very likely a change in speed on machine would change the speed of all waves, and point-gap machines differ. It is very likely the sphere gaps between the machines are equal—you might say so far as we know. It is the heat of wave which is important so far as therapy is concerned.

Mr. Ante. The diameter of the sphere is the exact diameter of the spark gap.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M.D., *Editor* · Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D. C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

WASHINGTON MEETING

The Twenty-second Annual Meeting of The American Roentgen Ray Society will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of The American Roenrten Ray Society. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

PRELIMINARY ANNOUNCEMENTS

Dr. A. C. Christie, President of the Society, announces that plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. Réné Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers on therapy than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it neces-

sary to attend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

X-RAY WORK FROM THE VIEWPOINT OF AN INTERNIST

The address by Dr. George Dock before the Central Section of The American Roentgen Ray Society is of more than passing interest. It is an appraisement, a critique, and an appeal. The roentgenologist whose medical training fits him to respond to this address will find therein a powerful incentive not merely to do better work but to do the best work. The words carry unusual weight because they were uttered by the one internist of the English speaking world upon whose shoulders has fallen the mantle of William Osler.

Dr. Dock's interest in *x*-ray work began with Roentgen's discovery. He watched it at first-hand abroad and at home. On his invitation the writer gave the first talk on the *x*-ray examination of the chest delivered at a great University where for many years he held the chair of medicine. It was due to his influence that the same University obtained its first appropriation of funds for an *x*-ray installment. His interest in this revolutionary means of diagnosis has expanded with its development, although he has never himself undertaken the technical part of the work.

But he has never ceased to be the skillful and cultured internist. The traditions of the great masters are no less dear to him now because a new science of diagnosis is being written. The stethoscope, the microscope and the test tube are still no less important because of the revelations of the tube and film. The fine art of taking histories and of making the physical examination is now, no less than in the days of Laënnec, the foundation of the diagnostics of internal medicine.

These ideals of the internist he would plant in the minds of the roentgenologist. The search for the pathognomonic sign, like the search for the philosopher's stone, is futile although strangely fertile in unexpected fruit. The work of diagnosis is not shortened by the discovery of new methods. It is amplified and more accurate, but yet in need as much as ever—perhaps more than ever—of the correlating power which comes only from a complete knowledge of the patient. The roentgenologist must refrain, therefore, from issuing diagnoses upon *x*-ray premises but give instead roentgen interpretations.

Doctor Dock's address is not sugar-coated. His criticisms are sharp and basic. His acidulous remarks are destructive of inferior methods but preservative of the best. However perfect may become *x*-ray technique and however skillful the roentgenologist, yet in the accumulated experience and achievement of pre-roentgen times lies a body of diagnostic methods which the medical world will never willingly let die.

However much we may admire the vigor, sanity and insight displayed by Dr. Dock we cannot but take issue with him over at least one point. This is the statement that the roentgenologist has never satisfactorily demonstrated his reasons for deciding upon the activity of a tuberculous lesion in the lung from a single examination. If he had said that the activity or quiescence of such a lesion cannot always be decided by a single examination we would unhesitatingly agree. In fact in a previous editorial in the Journal we emphasized the difficulties and dangers of diagnosticating activity from single *x*-ray examinations and urged the use of serial plates. But we believe that the pages of the Journal and the works of many roentgenologists without regard to nationality have clearly defined the distinctive attribute of the active pulmonary lesion when found on the *x*-ray plate. Un-

fortunately it is not present in all stages of activity or in all types of pulmonary tuberculosis. But when found it surpasses all other clinical signs in directness and simplicity. It is merely the nebulous, borderless character of the shadow of activity. Form and distribution may also be at times decisive factors, but it is the nebula which marks the focus in active evolution, the final end of which is the smaller dense calcification of quiescence.

The nebulous quality of the shadow depends upon the fact that activity means inflammation and inflammation means increased blood, serum and leucocytes in the lung tissue and these in turn mean density. The nebula may be parenchymatous or lymphatic or it may be seen as a halo about a calcified focus not yet wholly quiescent. Classifications still vary, but by lymphatic we mean a line or stalk of nebulous density running to the hilum from a small calcified particle well out in the lung field. In some cases scores of these radiation nebulous drainage lines may be traced, each one starting from a calcified particle about which is a soft halo. These may be seen best on stereoscopic films using double screens, the briefest possible exposure with a soft tube, and a long distance between tube and patient.

It may also be asserted and defended that good *x*-ray plates are always right and that only the interpretation is wrong. If a "large pneumothorax" or a "fairly extensive tuberculosis" is missed by the roentgenologist it is the man and not the method that is to blame. We cannot but believe that any pulmonary lesion which brings about changes in density is susceptible of *x*-ray demonstration.

The limits of an editorial allow us to be suggestive merely and we leave to other and more capable hands the full exposition of these and other points which Dr. Dock flings out as a challenge. We need the stimulus of such handling. We regret that he let slip the opportunity for good-natured but invigorating sarcasm regarding the roentgen diagnosis of gallstones. We are satisfied, however, that he has left few fallacies unprodded so far as the roentgen diagnosis of chest lesions is concerned.

There are two sides to every question. We enthusiastically agree with Dr. Dock that *x*-ray interpretation is greatly assisted by clinical data. But the converse is doubly true. Not only are clinical findings frequently reinterpreted by *x*-ray means but the internist himself has been trained to a skill formerly unattainable in thoracic diagnosis by the repeated disclosures of plate and screen.

In the last analysis the plate and screen are but the added resources of the internist. The thermometer, the stethoscope and the whole clinical laboratory were at first fought and disciplined before they were adopted as legitimate members of the family. We have reached the stage of being disciplined. May we not turn the tables and adopt the internist as a legitimate roentgenologist?

A. W. Crane.

EXTERNESHIPS AT MOUNT SINAI

There has been established at the Mount Sinai Hospital, New York City, a system of externeships in the X-Ray Department. There are to be two externes, each serving one year, one beginning February 1st and the other August 1st. The next appointment begins on August 1st, 1921.

OBITUARY NOTICE

The announcement has just been received of the death of Dr. Heinrich Ernst Albers-Schönberg, of Hamburg, an Honorary Member of The American Roentgen Ray Society. Dr. Albers-Schönberg died on June 4th at Allgemeines Krankenhaus St. Georg, Hamburg, from pneumonia. He was in his fifty-seventh year. An obituary will be published in a later issue of the Journal.

BOOK REVIEWS

SURGERY, ITS PRINCIPLES AND PRACTICE. Edited by William Williams Keen, M.D., L.L.D. 855 pages, 359 illustrations, 17 of them in colors. W. B. Saunders Company, Philadelphia.

This volume of Keen's Surgery is one of two volumes designed to complete this standard work on surgery up to the year 1919. Dr. Keen states in the preface that "these volumes do not only record the achievements of surgery from 1914 to 1919. They also fulfill a second purpose I have had in view, viz.; they make available for the surgery of peace the lessons taught us during the war."

Some of the chapter, such as those on "Inflammation" and "Syphilis," are supplementary to chapters in previous volumes. The high standing of the authors of these chapters is sufficient guarantee of their excellence.

A large part of the volume deals with war surgery, either directly or in its effect upon the surgery of civil life. This is indicated by such chapter headings as the following: "Organization and Administration of the Medical Department of the United States Army in War"; "Organization and Administration of the Medical Department of the United States Navy in War"; "Surgery in a Fighting Ship"; "'Traumatic' Hysteria including so-called 'Shell Shock'"; "The Bacteriology of War Wounds"; "Gunshot Fractures"; "The Pathology of Gunshot Wounds and other Injuries of the Nervous System"; "Military Surgery of Joints"; "Military Orthopedic Surgery," and "Military Surgery of the Vascular System."

The entire volume will undoubtedly take its place as a valuable part of a standard work on surgery which is itself quite invaluable to any one practicing surgery in any of its branches, or any specialty related to surgery.

It must seem to the roentgenologist, however, that the object of the author to "make available for the surgery of peace the lessons taught us during the war" has been quite inadequately met, so far as roentgenology is concerned. This is especially noticeable in the chapter by Ashford on "Organization of the United States Army in War." The service rendered by the x-ray during the war both to the internist and to the surgeon was so generally recognized that there seems to be little ground for argument on that point. The development of the bedside roentgen apparatus was carried to a high degree of perfection. Its use in assisting in the diagnosis of empyemas and numerous other complications during the influenza epidemic can hardly be overestimated. Since the war this apparatus has come into general use in civil institutions. The importance of the x-ray in determining the presence and in the localization of foreign bodies was so well recognized that it merits more than the casual mention accorded it. Possibly such considerations were thought to be beyond the scope of Colonel Ashford's chapter. Several pages, however, are given over to a description of portable laboratory apparatus and no mention whatever is made of portable x-ray apparatus. The portable x-ray apparatus developed by the Medical Department of the U. S. Army was a great advance over such apparatus used by other armies both in its portability and efficiency. It was used to do the unprecedented amount of x-ray work in evacuation hospitals, served as the x-ray equipment of mobile hospitals, and even some field hospitals, such as those with the 1st, 2nd and 3rd Divisions, were equipped with it and used it extensively.

The above criticism does not apply to the article on "Military Surgery of the Vascular System" by Matas. He states that "The extraction of foreign bodies from the heart, pericardium, and great vessels constitutes one of the crowning triumphs of surgery in the late war." This was due to two factors—the greater frequency with which artillery projectiles and explosive shells were used and the "more systematic and routine examination of thoracic organs by x-ray, not only radiographically, but radioscopically, which has revealed the presence of projectiles in the heart, pericardium, and great vessels where their presence was not even suspected." Ombredanne

and Ledoux-Lebard are quoted to the effect that examination of French sources shows a total of 2,000 extractions of projectiles made with assistance of radiographic and other localizing apparatus, with failure to extract the bodies in only three cases. It is impossible at the present time to give an estimate of operations on the heart for extraction of foreign bodies in all the armies, but accessible reports are sufficient to prove that "a deliberate, well planned surgical operation, especially in qualified hands, can be performed with a fair prospect of success."

Numerous cases are mentioned of migration of foreign bodies from the heart chambers into the blood vessels, both through arteries and veins, and also of migration from the vessels with lodgment in the heart.

Summary of the lessons bearing upon surgery of heart in general and upon extraction of foreign bodies in particular is as follows:

1. The indispensable association and collaboration of the radiologist with the surgeon for diagnostic and surgical purposes.

2. The proved efficiency of this combination has added vastly to the safety of intra-thoracic manipulations and to procedures for the extraction of foreign bodies which hitherto had been regarded as largely impracticable.

3. Modifications in the technique of thoracotomy which, utilizing the older suggestions and methods, have been revised and extended in the light of a new and larger experience.

4. The disregard of the pleura and of the risks of acute surgical pneumothorax, contrary to all preconceived notions of the gravity of this complication in antebellum days.

The radiologic peculiarities of projectiles in the heart are discussed. Radioscopy is preferable to radiography. In the auricular cavities according to Laurent of Brussels, M. Barnet, and Ledoux-Lebard, the foreign body has a whirling or oscillatory movement and exhibits very rapid and incessant motion. In the ventricles the movements are more definitely linear or pendulum-like in character. The movement of missiles in the myocardium is characteristic. One motion is vertical and the other horizontal and quite invariable, in contrast to the variable movements of a foreign body in one of the heart cavities.

It is impossible within the limits of this review even to touch upon many of the points discussed in this article. The entire section merits very careful study by the surgeon and roentgenologist.

In the chapter by Pool on "Military Surgery of the Joints" is the following paragraph:

The success of the operation depends largely upon the thoroughness of the roentgenologist's examination and the accuracy of his findings. His report should be made according to a definite system. The following routine has been found the most satisfactory.

"Anatomic site and size of each foreign body in millimeters, depth in millimeters, position of the part, if it is not in the anatomic position; bone lesions. For instance, 'Right knee, FB 10 x 15 mm., 50 mm. in depth, under the point marked on the skin, the limb being in 45 degrees outward rotation; comminuted fracture of internal condyle, no displacement."

In the chapter on "Orthopedic Surgery of Civil Life" is a paragraph on *x*-ray diagnosis of tuberculous bone and joint disease and on page 614 a description of the *x*-ray appearances in rickets.

It is to be hoped that the forthcoming volume of the *Surgery* will contain some account of the *x*-ray work done during the war, along many other lines, comparable to that in the section by Matas on "Military Surgery of the Vascular System."

A. C. Christie.

Roentgen Interpretation; A Manual for Students and Practitioners. By George W. Holmes, M.D., and Howard E. Ruggles, M. D. Second Edition. Pages 228. Illustrations 184. Price $3.25. Lea & Febiger, Philadelphia and New York, 1921.

This book has been entirely rewritten and much has been added to the text. Illustrations have also been added. The quality of the paper used in the present edition is much better than in the first, and this greatly enhances the illustrations. The table indicating the appearance of centers of ossification is of extreme interest. The chapter dealing with heart examinations describes the method in use at the Massachusetts General Hospital for the past five years and should be in everyone's possession. The illustrations are good.

TRANSLATIONS & ABSTRACTS

WITHERS, SANFORD. Carcinoma of the Eyelids Treated with Radium. (*Am. J. Opth*, January, 1921.)

Eight cases are reported as representative of over one hundred similar cases. In most of the cases, from 25 to 50 mg. of radium were used, filtered by the glass capsule wall and 0.2 to 0.3 mm. of silver and 0.5 to 1.0 mm. of gum rubber. The surrounding tissues were protected by lead. In those cases where it was imperative to protect the globe and the ocular conjunctiva, Dr. Withers used oval lead screens, molded to fit the globe. These were dipped in melted paraffin, and were introduced after the instillation of a few drops of liquid vaseline. The total dosage varied from 500 to 900 mg. hours; the dosage per square centimeter of tumor surface ranged between 60 and 500 mg. hours. Pathologically these growths of the lids are made up of basal cells, with little stroma, and are relatively benign. In the presence of scar tissue, which breaks down easily under radiation, the results are less favorable. The author calls attention to the fact that cataracts disappear under radium, and that cautery doses of radium remove pterygia. The sclera is very resistant, even to cautery doses of radium, and the conjunctiva reacts more quickly and is more rapid in its repair than the epithelium of the eyelids. In general radium is the method of choice in the treatment of carcinoma about the eyelids.

LOWELL S. GOIN

QUICK, DOUGLASS. Clinical Results of Treatment of Nerve Tissue Tumors by Radium. (*Proc. N. Y. Neurol. Soc.; J. Nerv. Ment. Dis.*, February, 1921.)

The general opinion is that pressure symptoms due to pituitary tumors may be relieved by the use of radiation. Three cases are reported, of which one died and two were improved. Neurosarcoma is a discouraging condition. A given area may be destroyed but recurrence may take place elsewhere along the course of the nerves—not necessarily by continuity. Surgery and radium should be judiciously combined; operation should not be resorted to unless radium can be buried in the tumor if it is found possible. Two cases, one of a cerebral neoplasm successfully treated with radium, and one of an anaplastic glioma with improvement are reported.

L. S. G.

HOUDMONT, H. AND DAUTREBANDE, L. The Radioscopic Examination of the Heart. (*Arch méd. belges*, December, 1920.)

The image obtained by simple radiography is deformed by distance, by the angle of entry of the central ray, and by the pulsations of the heart. It is useless except for verification of position, pericardial lesions, or in examination for aneurysm.

Teleradiography gives a fairly exact image but is rather difficult, requiring powerful installations. Stereoscopic plates of the heart have no value. Orthodiagraphy is the method of choice. Two methods are described. Examination is carried out with the patient in various positions in relation to the screen. Each part of the heart corresponds to a position in which it may be studied with the greatest facility. Examination in the oblique position affords a means of study of parts of the heart inaccessible to ordinary clinical methods.

In functional disorders of the heart, emphasis is laid on the necessity of excluding such conditions as pleural adhesions, encysted pleuisy or large colonic or gastric gas accumulations. A number of charts for comparative measurement are included. The area of each ventricle may be calculated by the reconstruction of the interventricular and the auriculoventricular septa. Emphasis is placed on the importance of the angle of disappearance of the apex behind the vertebral column, and the left ventricle is thus measured. The normal angle of disappearance is 30 degrees. A resumé of the findings in the various organic heart lesions follows. The authors conclude:

(1) *X*-Ray examination of the heart must become a more regular part of the study of the heart.

(2) Radiographs are practically useless; orthodiagraphic calculation offers the only information of any value.

L. S. G.

Eden, T. Watts, and Provis, F. Lionel. A Record of Seventy-six Cases of Uterine Fibroids and Chronic Metritis Treated by the *X*-Rays. (*Lancet,* Feb. 12, 1921.)

The cases presented include 46 cases of uterine fibroids and 30 cases of chronic metritis. About 10 per cent of the cases were less than forty years of age. The cases were selected on the basis of age, size of the tumor, character of the hemorrhages, degree of anemia, and the presence of complications.

They have rarely(8 cases) treated patients less than 38 years old, wishing to conserve the ovarian secretion in patients who were younger. Tumors which exceeded the level of the umbilicus in height were rejected. In cases of irregular and interval bleeding the uterus should be first explored to exclude malignancy. Patients profoundly ex-sanguine were advised to submit to hysterectomy, as the first and second treatments may be followed by increased bleeding. Inflammatory disease, malignancy, and a degenerative tendency in the tumor were considered contra-indications for treatment. The cases for chronic metritis were so labelled for convenience, if no marked enlargement or irregularity in outline of the uterus could be detected.

The authors used from 20 to 30 ma. minutes with a water-cooled tube backing up 8 or 9 inches, and with filtration of 3 mm. of aluminum, and a loofah sponge enclosed in a chamois leather bag with four layers of satrap paper. Six or eight areas on the anterior abdominal wall and four on the posterior wall are irradiated. This dose is not repeated until three weeks have elapsed. The most advantageous time for treatment is shortly after a menstrual period. Nervous symptoms attendant upon the artificial menopause thus produced seemed to be less severe than in the normal menopause.

The authors conclude:

(1) *X*-Ray treatment is the method of choice for uncomplicated cases of severe hemorrhage due to metritis, or other conditions in which neoplasm is not present, and in—

(2) Fibroids not exceeding in size the level of the umbilicus, if the patient is over 38 years old, if the hemorrhage is the regular monthly type and if there are no contra-indications.

(3) All cases should be submitted to a careful gynecological examination before *x*-ray treatment is administered.

(4) The risk of failure with *x*-ray treatment is negligible with properly selected cases.

L. S. G.

Ewing, James. The Structure of Nerve Tissue Tumors with Reference to Radium Therapy. (*Proc. N. Y. Neurol. Soc.; J. Nerv. & Ment. Dis.,* February, 1921.)

The structural characters which determine susceptibility to radiation are a cellular character, an undifferentiated form of the cells, rapid growth with an abundance of mitoses, vascularity (especially when due to abundance of delicate capillaries), and the absence of much inter-cellular substance. Neurofibroma might be affected by radium, especially if the radium is applied directly to the tumor. True angio-endotheliomata occur in the rare diffuse sarcoma of the spinal meninges, and should be susceptible to radium. Angiosarcoma should be markedly influenced by radium, since its nutrition is unstable, but whether slow and safe regression can be accomplished, especially with bulky tumors, is doubtful. Glioma presents most of structural features that favor radio-susceptibility. Primary carcinoma of the brain has a structure indicating a high degree of susceptibility to radium. Hypophyseal struma with acromegaly has been definitely influenced by *x*-rays directed through the temporal regions.

L. S. G.

Frank, Louis. Carcinoma in the Cervical Stump after Supravaginal Hysterectomy; and the Radium Treatment of Carcinoma of the Cervix. (*Am. J. Surg.,* Vol. xxxiv, No. 6.)

The coincidental development of cervical and corporeal carcinoma is unusual. The problem of etiologic relationship between carcinoma and fibromyomata remains unsolved, but it is interesting to note that uterine carcinoma occurs in women who have fibromyomata five times as frequently as in those who have no such condition. The development of carcinoma in the cervical stump after supravaginal hysterectomy is rare, less than eighty cases having been recorded in the

world's literature. Radical surgery has produced few cures after the pelvic viscera have become involved in a carcinomatous process. According to Janeway, an elaborate search of the United States discovered only 61 women operated on between 1911 and 1916 who had been cured of cervical carcinoma. The writer cites 38 cases (three of which are reported in detail) of carcinoma of the cervix treated with radium. The three detailed cases received doses of 1200, 2400 and 3600 mg. hours respectively. The dosage at each application was in one case 600 mg. hours and 1200 in each of the two others. Of the thirty-eight cases treated, 18 are well (some of them for two years), 4 show no local evidence of disease but are not well, 11 have died, and 6 cannot be traced.

L. S. G.

Stevenson, Walter C. The Effects of Radium Treatment on War Injuries in the Neighborhood of Nerves. (*Brit. Med. J.*, June 26, 1920.)

The writer reports twelve cases of old nerve injuries markedly improved by radium treatment. He concludes that while radium cannot benefit gross nerve lesions, it does improve the nutrition in the area supplied by injured nerves, and it appears to aid and hasten the return of function in a limb after milder degrees of nerve trauma.

L. S. G.

Ulrici, H. So-called Hilus Tuberculosis. (*Beitr. z. Klin. d. Tuberk.* October 23 1920, xlvi, l.)

In pulmonary tuberculosis in the adult, the localization of the disease in the bronchial glands which is invariably present has almost always regressed to such a degree as to be seldom demonstrable either by clinical, physical-diagnostic or radiologic resources. As a rule only foci of lime are recognizable as such in the plate. In children conditions are quite otherwise. Here the bronchial glands are of great significance in the genesis of pulmonary tuberculosis. In adults there is practically no pulmonary tuberculosis which has originated in the hilus. The shadow pattern in the plate which has given rise to the contrary impression is due to a confluence cirrhosis of the hilus area, or to a caseous pneumonia which begins centrally—for this latter condition indeed the shadow is pathognomonic. In the adult, pulmonary tuberculosis begins almost invariably in the apex or sub-apex, not only in the side of the hilus originally, but in the opposite side as well. The broadening of the isolated hilus shadow and the reinforced outlines of the lung have nothing to do with pulmonary tuberculosis proper.

Ledoux and Caillods. Sacralization of the Fifth Lumbar Vertebra. (*Presse méd.*, Par., Feb. 13, 1921, xxix, 13.)

In the space of a few months the authors have recognized by radiography no less than 7 cases in which the last lumbar vertebra was incorporated with the sacrum. Nové-Josserand, the well known orthopedist, had called attention to this condition as a cause of various painful manifestations in the lower extremities. He however regards it as very rare while the authors think it may be fairly common, judging from their own experience. The characteristic *x*-ray find is a considerable and symmetrical enlargement of the transverse process of the fifth lumbar vertebra. The shadow of this process suggests the tail of a fish, while when both are considered the resemblance to a butterfly's wings is mentioned. The enlarged process is in contact for a considerable extent with the ilium and upper border of the wing of the sacrum. Compared with the radiograms of Nové-Josserand the condition seen by the authors seems more advanced. Since the last lumbar vertebra is consolidated with the sacrum the enlarged and bifid transverse process suggests an accessory wing of the sacrum superposed on the normal wing. Embryology teaches us that the latter is really the transverse process of the first sacral vertebra. As a result of the malformation the normal lumbo-ilio-sacral interspace through which passes the fifth lumbar nerve is not only much reduced in size but becomes a sort of sacral foramen. While the symptoms do not usually appear in childhood, one of the author's patients was but five years old. The period at which the ossification of the lumbar vertebra to the sacrum occurs has not been determined. The original ossification of the spine

should be complete by the ninth year, while the so-called secondary ossification extends from the ages of fifteen or sixteen to those of twenty-two to twenty-five. This phenomenon has been associated with a disturbance of secondary ossification, but the case of the child of five appears to invalidate this view.

LEHMANN, J. C. Carcinoma Dosage, with Especial Consideration of Carcinoma of the Breast. (*Zentralblatt für Chirurgie*. Leipzig. Vol. xlvii, No. 13, p. 290, March 27, 1920.)

The author points out that to-day practically every surgeon gives patients with carcinoma of the breast prophylactic raying following an operation. He has followed this method for the last seven years and freedom from recurrences for a period of three years has increased. In cachetic patients carcinomas are in no way sensitive to roentgen rays while in senile persons carcinomas are frequently of slow growth and easier to check with roentgen rays.

In chancroid of the lip considerably more than 100 per cent of the erythema dose is required; radium will be usually more efficacious than roentgen rays.

While some progress has been made in the use of the roentgen rays as applied to carcinoma of the breast, the author warns against being over-jubilant lest the method be brought into discredit.

ROBERTS, J. E. H. Oxygen Inflation of the Peritoneal Cavity for Radiographic Purposes. (*Brit. M. J.*, p. 742, Nov. 13, 1920.)

The method of distending the peritoneal cavity by oxygen gas, which was introduced by Weber in Germany, followed by Rautenberg and Goetze in Germany, Stewart and Stein in America, and Alesandrini in Italy has proved to be of great value in exact clinical diagnosis. By allowing the separation of the liver and spleen from the diaphragm, it has enabled the outlines of these organs to be seen for the first time. By compressing and displacing the empty intestines it enables the other solid viscera and abdominal tumors to be examined.

The objections to the method are largely theoretical and no ill consequences have occurred in the fifty cases the author has inflated, nor in any of the many cases of which published records exist.

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STUDIES IN REDUCTION OF BONE DENSITY*

By D. B. PHEMISTER, M.D.

CHICAGO, ILLINOIS

REDUCTION in bone density occurs either from a retardation of bone deposition in the presence of normal bone absorption, or from excessive bone absorption. Retarded deposition occurs in disorders of calcium metabolism, such as rickets and osteomalacia. Calcium absorption goes on at the normal rate, and new connective tissue framework or osteoid tissue continues to form but fails to ossify. This is one of the factors that result in gradual reduction of the calcium content and replacement by fibrous tissue. Reduction in density from excessive bone absorption occurs almost entirely as a result of regional or local disturbances produced by disease, injury or loss of function. This discussion will be limited to reduction in density produced by bone absorption.

Lime salts may be removed from the bone by two processes: first, solution by the serum, leaving the connective tissue framework behind, and, second, cellular activity, where the bone is directly attacked by fixed tissue cells, removing both lime salts and stroma. Solution of lime salts by the serum, leaving behind the connective tissue framework, is said to occur in rickets and osteomalacia. Von Recklinghausen described the process as halisteresis, and claimed that by means of special stains and gas injections of the fresh bone he could demonstrate empty spaces from which the lime salts had been absorbed. Recent histologic studies, especially by Axhausen, cast much doubt upon the occurrence of such a process, and show that bone absorption is produced almost entirely by the direct action of fixed cells known as osteoclasts. The osteoclast may be an abnormal cell, as in tumors or inflammations, or it may arise from alteration in function of the cells in the vicinity. Cells may be converted into osteoclasts without change in form, or they may be transformed into giant cells. In many processes the greater amount of bone is absorbed by cells without any alteration in their morphology. The nature of the reaction by which the cell produces absorption of the lime salts is imperfectly understood, but it is probably by the creation of an acid medium in direct contact with the bone, which results in its solution. The field of absorptive activity is confined to a comparatively narrow space about the cell.

There is no specific osteoclast, and a variety of cells may possess this absorptive power in common. Most bone absorption is produced by fibroblasts and endothelial cells whose functions have been altered, or by giant-celled osteoclasts, to which they give rise. Tumor cells and inflammatory cells of

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14-17, 1920.

various types may possess the power of bone absorption. Different histologic pictures arise in the process of absorption, in which the osteoclasts attack the surfaces of the bone absorbed, eating various-sized and shaped pockets in it. Smooth absorption is another form in which lime salts disappear from cellular activity along the walls of the haversian canals without extensive pocket formation. Volkmann's canalization is the process in which marked dilatation of the transverse or communicating canals is produced by greater absorption in their vicinity than occurs along the haversian system. Ernst and von Muralt have described the condition of lamellar splitting off and fragmentation produced by tumor cells which invade the interlamellar spaces.

Reduction in density may be local, regional or general, according to the cause. In most local processes there is both local and regional reduction in density, and if general symptoms are marked and extend over a long period of time with confinement to bed, there may be general reduction in density. The fields for discussion here have been chosen more or less at random, without any attempt to cover the entire subject. The object is not

FIG. 1. Staphylococcus bone abscess of external supracondylar region of humerus. *a*—Area of bone destruction without sequestrum formation.

FIG. 2. Acute osteomyelitis of tibia of eleven days' duration. Small, irregularly distributed areas of reduced density in end of shaft, being the earliest *x*-ray findings in osteomyelitis. Subsequent changes showed in entire length of shaft.

so much to show roentgenologic features of reduced density as the histologic processes by which the bone is destroyed.

In bone infections there are four processes

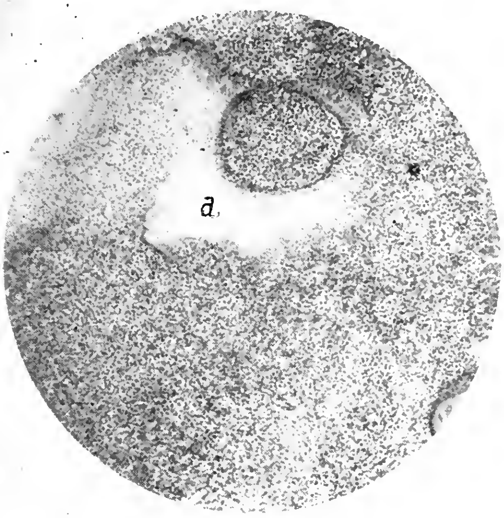

Fig. 3. Bone destruction in osteomyelitis of two weeks' standing, produced by fresh granulations before the appearance of giant-celled osteoclasts. *a*—Dead bone.

by which reduction in density may be produced: first, there is destruction of dead bone at the seat of greatest inflammatory activity; second, there is local destruction of living bone, or caries; third, there is rarefying osteitis in the neighboring living bone for variable distances about the area of complete bone destruction; and, fourth, there is regional atrophy of disuse. The amount of each of these forms varies considerably with the nature and severity of the inflammatory process, and is of considerable importance in the differential diagnosis of inflammatory bone changes. There are no specific destructive changes for the individual inflammatory processes, any more than there are specific productive changes. The description which follows is of the usual reduction in density which occurs in the various inflammatory processes to be enumerated.

Osteomyelitis.—Necrotic bone results from the effect of the toxins in the most severely inflamed region. The unossified elements of the dead bone are rapidly killed by toxins and removed by the action of the serum and leucocytes, but the calcareous deposits are little affected during the height of the inflammation, because practically they are only re-

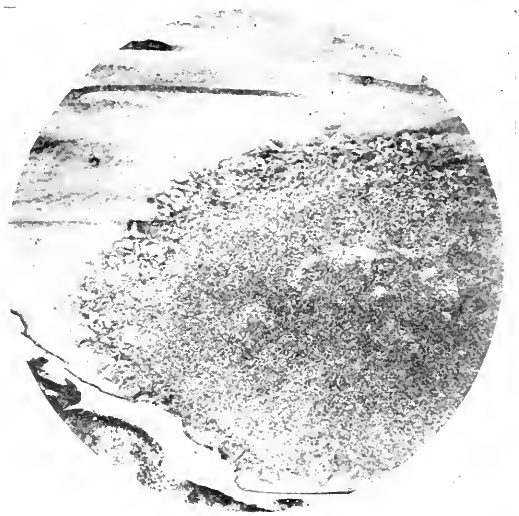

Fig. 4. Lacunar absorption of sequestrum of two months' standing by giant cells and maturing fibroblasts. Note the lacunae along the entire line between dead bone and granulations.

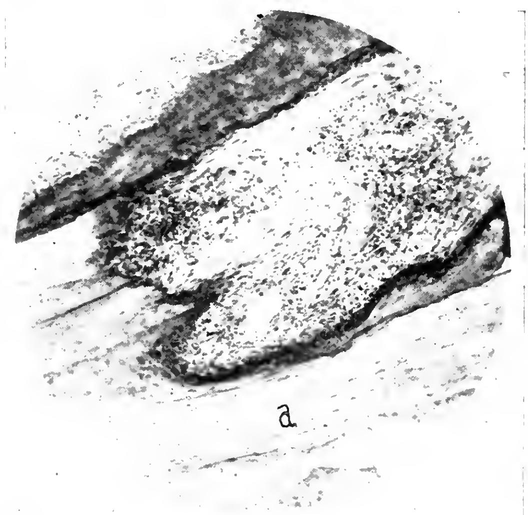

Fig. 5. Rarefying osteitis about periphery of osteomyelitis of fibula of ten weeks' standing. Shows absorption by maturer type of inflammatory tissue. *a*—Living bone.

moved as a reparative process by the absorptive action of the granulations, and some time is required for the development of reparative changes and the absorption of

sufficient bone to produce evidences of reduction in density. From six to fifteen days elapse, depending upon the size of the bone and the location of the infection, before signs of reduction in density can be shown by the *x*-ray. If the osteomyelitis is a diffuse process, the reduced density shows first in small scattered areas of the metaphysis, and evidence of involvement of thicker portions of cortex appears later.

Absorption of living bone in considerable quantity occurs about the margin of dead bone, helping in the sequestration of the dead bone and leading to cavity formation. This process is known as caries. Early in osteomyelitis the absorption of both living and dead bone is produced by active granulation tissue. After the acute inflammatory stage has subsided, the granulations become somewhat more mature and large numbers of giant cells appear, interspersed among the fibroblasts. Lacunar absorption is the process by which the lime salts are removed in both stages. Figure 1 shows an abscess cavity in localized osteomyelitis, produced by the rapid destruction of spongy bone, and Figure 2 small scattered areas of destruction in the metaphysis, showing early in diffuse osteomyelitis. Figure 3 shows the type of granulation tissue in the early stage, producing the absorption of both the dead and living bone in the formation of such areas. Figure 4 shows the maturer type of granulations and giant cells producing absorption of the dead bone some time after the acute inflammatory stage has subsided. The rate of destruction of dead bone by granulations depends to a considerable extent upon its relation to living bone. The surfaces of dead bone that are adjacent to living bone, as dead cortex is to involucrum, become extensively eroded from the action of granulations that are maintained in contact with them by the living bone. But surfaces remote from living bone frequently show little evidence of destruction, because of the absence of a bony background for the granulations. Large surfaces of dead cortex, uncovered by involucrum, may remain uneroded for months and the bone preserve its original density. Erosion of dead bone reduces its density, but the reduction is uneven because of the fact that destruction is of a worm-eaten type, as contrasted with the even reduction in density of atrophied living bone.

Rarefying osteitis arises from extension of the inflammation for a variable distance into the surrounding living bone. It results in the absorption of numerous, irregularly distributed, small areas of cortex or spongiosa, which shows in roentgenograms in from two to six weeks as corresponding areas of reduced density. Absorption in this process is produced early by the action of fresh granulation tissue, and at a later stage by mature connective tissue and giant cells. Extensive rarefying osteitis is seen in Figure 6. Figure 5 shows histologically rarefying osteitis in osteomyelitis of the fibula of ten weeks' standing. Rarefying osteitis is often entirely absent, especially in localized bone infections.

Regional Atrophy.—Atrophy of the living bone of the involved region results from disuse, and its severity depends upon the degree and duration of the disability. It may also be caused partly by the alteration in circulation and by the toxicity of the part. The first *x*-ray evidences of it are seen in the spongy bone in from two to four weeks. It is frequently spotted in this location, especially when the process has become advanced. It appears later in the cortex, and is somewhat more marked in the endosteal than in the periosteal region. Because of the greater absorption of cortex from within outward there may be considerable increase in diameter of the medullary canal. Absorption occurs along the course of the haversian canals, and when marked may give rise to longitudinal streaking in the roentgenograms. Figure 7 shows reduced density and longitudinal streaking of cortex in a specimen of marked eccentric atrophy of the femur. Bone absorption in regional atrophy is produced largely by the action of simple fibroblasts arranged along the surfaces of the lamellae. The surfaces may remain smooth, and there

is absence of giant cells and lacunae in large numbers as contrasted with the destruction in the areas of inflammation where lacunae form. Figure 8 is of a cross section of an ulna showing marked eccentric atrophy and dilated haversian canals, the result of disuse, seven months after excision of a more distally located segment of the bone for sarcoma. Figure 9 shows the histologic appearance of a markedly atrophied cortex in the vicinity of an infected compound fracture of nine months' duration. It shows smooth absorption by fibroblastic osteoclasts along the surfaces of the lamellae. In general, the presence of large numbers of lacunae is more indicative of inflammatory action than of simple atrophy of disuse.

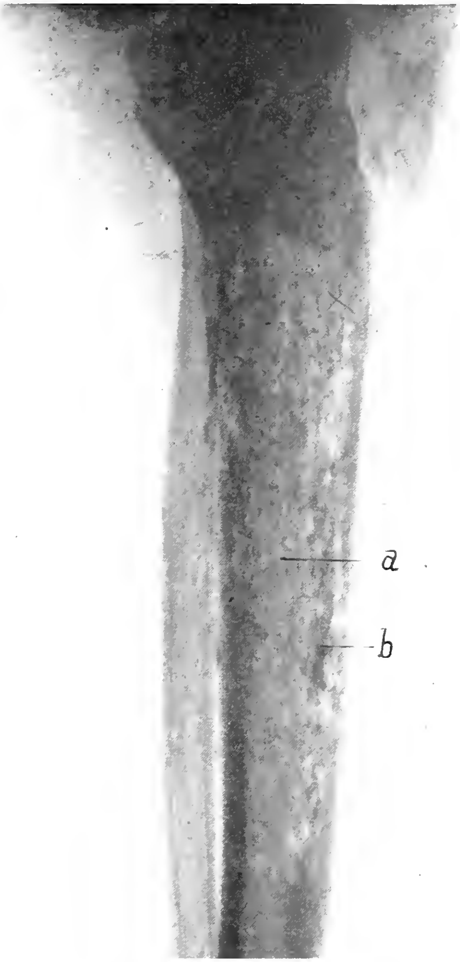

Fig. 6. Osteomyelitis of tibia, fifty-four days' duration, with (*a*) rarefying osteitis, (*b*) sequestrum formation and beginning regional atrophy in the non-osteomyelitic portions.

Fig. 7. Reduced density and longitudinal streaking in marked eccentric atrophy of disuse of femur.

Tuberculosis.—Tuberculosis usually produces localized osteitis, diffuse tuberculous osteomyelitis of the shaft being a comparatively rare occurrence. The metaphyseal region of the end of the bone is more frequently involved primarily, especially during the first decade. After the tenth year primary foci in the epiphyses are seen with increasing frequency. The lesion in either case causes death of bone in a circumscribed area, which because of the vascular arrangement is frequently cone shaped and in other cases roughly spherical.

The bone is frequently destroyed as rapidly as it dies, so that no sequestra are left in the field, and only cavity formation is seen in the x-ray (Fig. 10). In other instances where rapid death occurs, a line of demarcation forms and a sequestrum is left (Fig. 11). In this case reduced density is seen, indicative of the presence of a cavity which contains a sequestrum casting a shadow of the density of the bone at the time of its death.

Caries of the adjacent living bone may lead to gradual enlargement of the cavity after the early and more acute stage is passed. Lacunar absorption of the living and dead bone in the tuberculous focus is produced by the action of the granulations and giant-celled osteoclasts. Epithelioid and Langhans' giant cells are not seen to produce bone absorption, although they may be present in the immediately surrounding tissue (Fig. 13).

Rarefying osteitis from irregular spread

FIG. 8. Cross-section of ulna showing eccentric atrophy and dilated haversian canals, the result of disuse.

FIG. 9. Marked dilatation of haversian canals of cortex of humerus from smooth absorption in regional atrophy and dilated haversian canals, the result of disuse in osteomyelitis.

FIG. 10. Tuberculous caries of upper metaphysis of humerus, producing large area of reduced density without sequestrum formation. Note laminated periosteal new bone laterally.

of the tuberculous infection into the surrounding living bone is not seen, except in the rare cases of diffuse tuberculous osteo-

FIG. 11. Cone-shaped tuberculous focus of metaphysis in lower portion of neck of femur. Its periphery shows reduced density from caries, while the center shows normal density due to presence of (*a*) sequestrum.

myelitis, in which event density is irregularly reduced, as in similar cases of pyogenic osteomyelitis.

Regional atrophy occurs in tuberculosis, as in pyogenic infections of the bones, and produces the same histologic picture and type of reduced density as shown by the *x*-ray. It is frequently extreme, because of the protracted and painful nature of the disease.

In tuberculous arthritis, either primarily synovial or secondary to rupture of an osseous focus, a variety of changes may occur in the articular surfaces of the bones. Ingrowth of tuberculous granulation tissue beneath the articular cartilage, from about its margins, is a common occurrence, leading to destruction of the articular cortex of bone and to disappearance of the sharp line which it normally casts in the *x*-ray. Ordinarily the overlying articular cartilage is soon destroyed by the action of the granulations, so that not

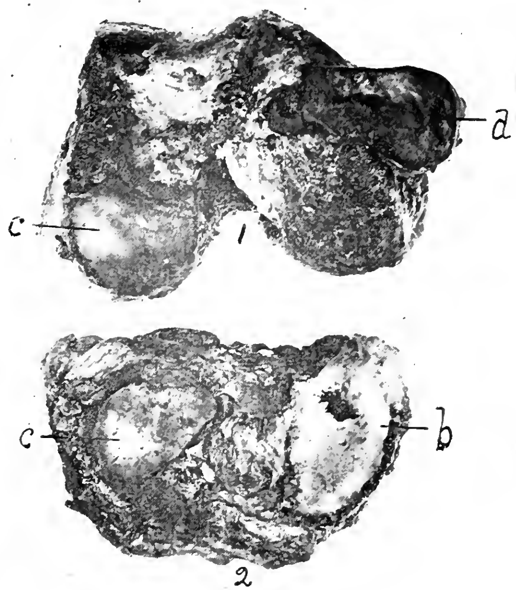

FIG. 12. Articular surfaces of (1) femur and (2) tibia from resected tuberculous knee of one year's duration. *a*—Undermined cartilage displaced, *b*—undermined cartilage in position, *c*—islands of attached cartilage.

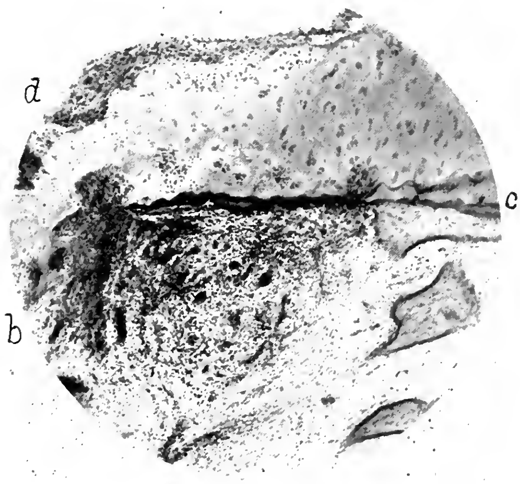

FIG. 13. Tuberculous granulations showing *a*—destruction of articular cartilage from the joint side and *b*—destruction of bone with undermining of cartilage; at *c*—bone and cartilage are unaffected.

only the articular margin of the bone is removed, but the cartilage space of the joint is markedly narrowed or obliterated. However, a considerable amount of the undermined articular cartilage may remain for some time after destruction of its underlying bony attachment, as is frequently seen at operation and is shown grossly in Figure 12 and microscopically in Figure 13. In such cases the cartilage space may be largely preserved in the roentgenogram, even though the sharp line cast by the articular cortex is fragmented or destroyed.

In other cases the tuberculous process invades and produces necrosis in certain areas of the ends of the bones, frequently to the depth of one or two centimeters. The dead bone subsequently either breaks down or becomes separated as sequestra. If the bony invasion occurs primarily or early in the course of the tuberculous arthritis, before regional atrophy has developed, the sequestra consist of unatrophied bone and subsequently cast a heavier shadow in the x-ray than the surrounding living bone which atrophies (Fig. 14). If the bony invasion occurs late and after the regional atrophy has developed, the shadows cast by the sequestra are of the same density as that of the surrounding living bone.

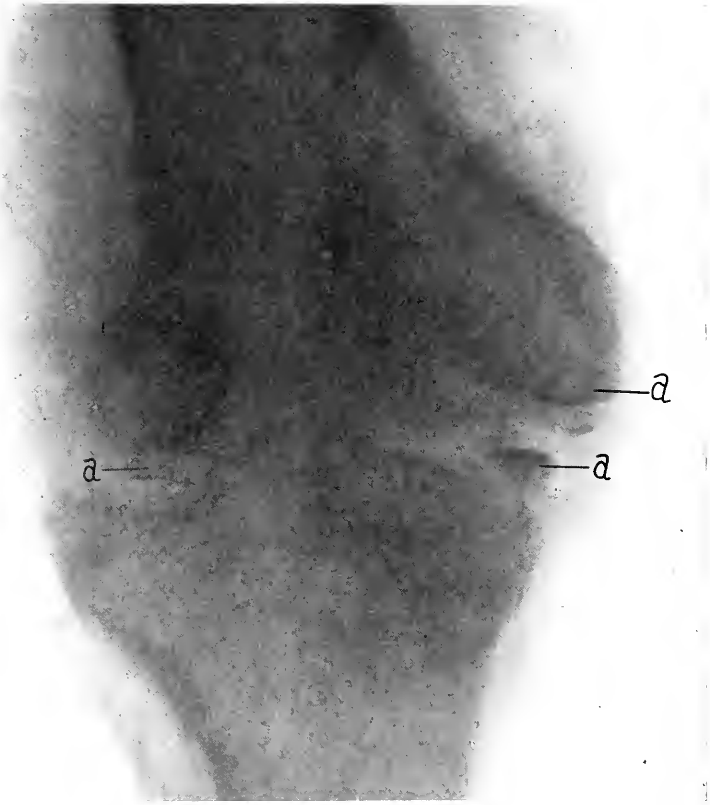

FIG. 14. Tuberculosis of knee of two years' duration with invasion of condyles and internal tuberosity and (*a*) sequestrum formation. Sequestra have sharp articular surfaces and are denser than surrounding living bone which subsequently atrophied.

Syphilis.—Bone syphilis produces gummatous caries in irregularly distributed and various-sized areas (Fig. 15). This may shade off into rarefying osteitis of the surrounding bone. A single area of reduced density of long duration speaks against syphilis, as the process usually extends, leading to multiple areas of bone destruction. Sequestra of appreciable size are rarely seen in syphilis of the long bones, but are sometimes found

in extensive involvement of the skull. Regional atrophy of the living bone is usually slight or absent in syphilis, because function is less interfered with than in osteomyelitis or tuberculosis. Hence reduction in density in bone syphilis takes the form of localized, irregularly distributed, large and small areas. They are frequently interspersed with shadows from new bone formation. Hypertrophic sclerosing syphilis with great increase in density usually shows small, irregular areas of reduced density, which are of great help in the *x*-ray recognition of the nature of the disease.

Fig. 15. Acquired syphilis of humerus of twenty months' duration. Numerous irregularly distributed, various-sized areas of reduced density and surrounding areas of increased density.

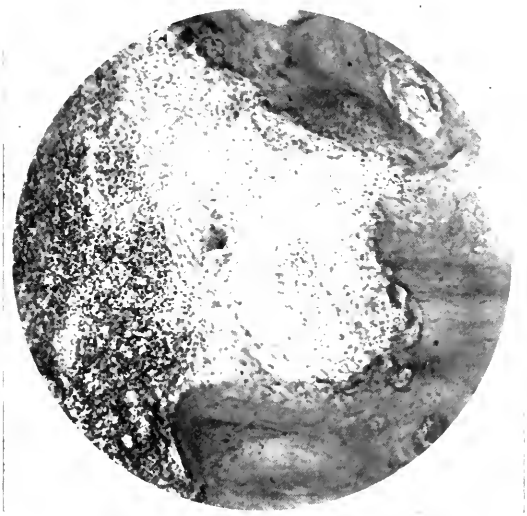

Fig. 16. Syphilitic caries of skull, showing bone destruction and gummatous tissue.

Fig. 17. Metastatic osteoclastic carcinoma from breast, almost completely destroying radius.

Histologically bone destruction with marked lacunar formation is produced by gummatous tissue. Fibroblasts and giant-celled osteoclasts produce the destruction, but epithelioid and syphilitic giant cells may be seen in close proximity to bone that is being eroded (Fig. 16).

Bone Tumors.—Reduction of density in bone tumors results almost entirely from breaking down of living bone by cellular

activity. However, aseptic dead bone may occasionally be seen where portions of cortex are cut off and completely surrounded by tumor which undergoes necrosis. Regional atrophy may also arise from disuse, where

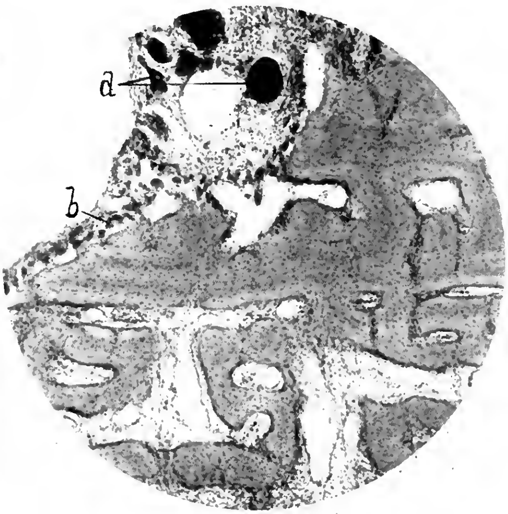

Fig. 18. Carcinoma metastasis of femur from breast, with absorption produced by non-tumorous giant cells. *a*—Carcinoma islands. *b*—Row of osteoclasts.

the tumor produces pain and much loss of function. Bone destruction reducing density is accompanied by extremely variable amounts of new bone formation, and the extent and distribution of the two must be taken into consideration in the recognition of the nature of the lesion.

Carcinoma.—In metastatic carcinoma of the bones, the relative amounts of bone destruction and new bone formation bear some relation to the seat of the primary tumor and its degree of malignancy and rate of growth. Thus metastatic carcinoma of the breast tends to produce bone destruction with little associated new bone formation, while carcinoma of the prostate produces little bone destruction and much new bone formation. However, slowly growing scirrhous cancer of the breast may produce marked ossification, and medullary carcinoma of the prostate occasionally produces marked absorption of bone with little associated ossification. Reduction in density arises from absorption of tumor which lodges and develops in the interior of the bone, whether shaft or cancellous portion is involved. Superficially situated metastases producing destruction from without inward are extremely rare. Very marked absorption affecting the entire length of a bone occasionally occurs without appreciable extension of the tumor beyond the normal limits of the bone. Figure 17, an extreme example, is of a metastasis in carcinoma of the breast, in which the radius was almost entirely destroyed without appreciable tumor formation in the forearm. Histologically the absorption is produced largely by the action of fibroblasts and giant cells, which form a narrow zone between the growing carcinoma and the bone that is being eroded. Figure 18 shows this process in osteoclastic metastasis of the femur, secondary to carcinoma of the breast. Carcinoma cells may also act as osteoclasts, coming in direct contact with the bone and leading to its absorption. However, their rôle is a minor one in the process of bone destruction. Figure 19 shows tumor osteoclasts in the same case as Figure 18. But even in this field

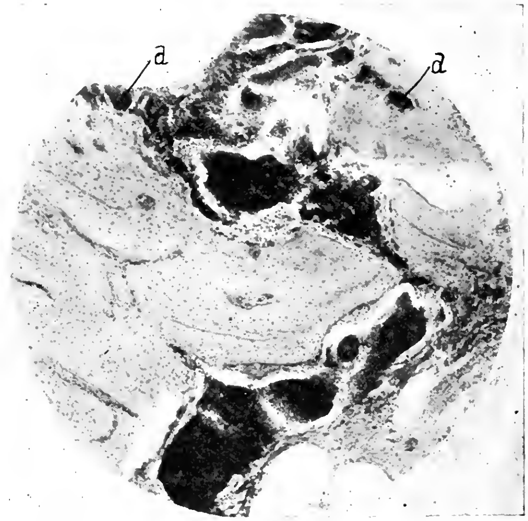

Fig. 19. Same case as Figure 18, showing bone absorption by carcinoma cells. *a*—Carcinoma osteoclasts.

many of the osteoclasts are mesoblastic cells. After the lime salts have been removed, the decalcified stroma and bone cells may not be immediately destroyed, and sometimes may

be seen as a narrow layer separating tumor from bone. Arey claims that bone cells thus liberated may be converted into osteoclasts and in turn take part in the process of bone absorption.

Sarcoma.—Reduction in density in sarcoma usually occurs *en masse*, and while the outline of the area of destruction may be irregular, extensive pocket formation and adjacent islands of destruction are uncommon. The appearance of trabeculation and pocketing may be produced by new bone formation. The area of destruction in sarcoma, beginning about the periphery of the bone, is usually in the shape of a shallow depression along the surface of the shaft (Fig. 20). If the involved cortex is thinner at one end than at the other, the depth of the destruction may be greater at the end where the cortex is thinner, because of the greater ease with

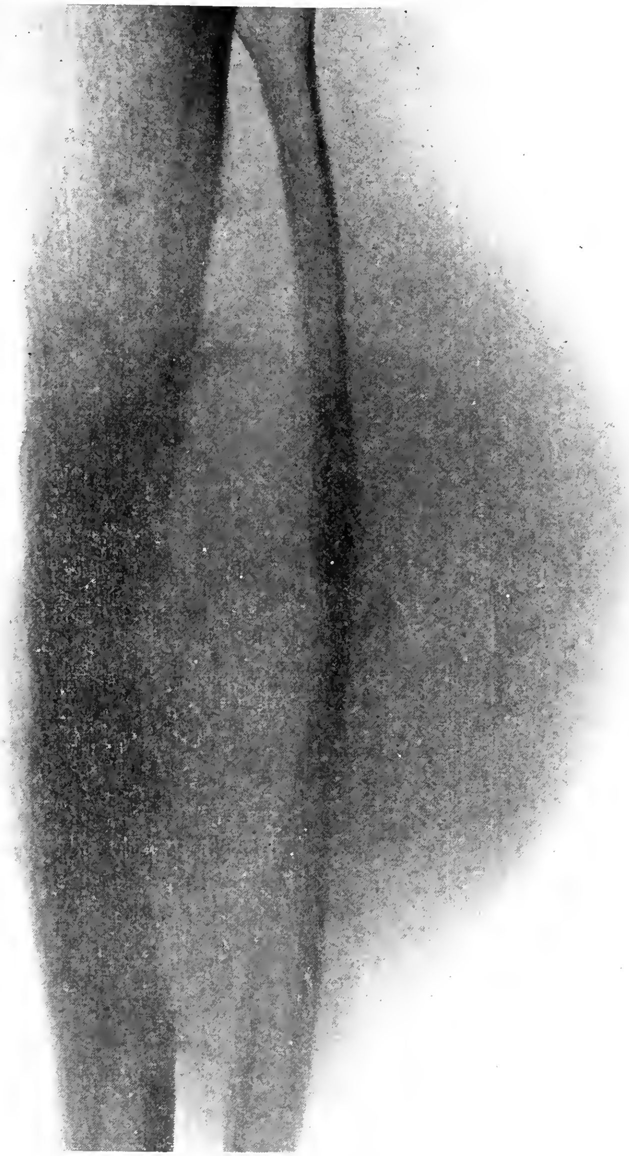

FIG. 20. Primary peripheral sarcoma of tibia, producing irregular, shallow, concave destruction of cortex of tibia and, by secondary involvement, of fibula.

which extension occurs into the deeper portion after the thin cortex has been eroded. Central sarcoma of the malignant type erodes the bone from the endosteal side, and usually more extensively in a particular segment of the cortex where it breaks through and forms

Fig. 21. Sarcoma eroding cortex of fibula by direct action of tumor cells. *a*—Tumor osteoclasts. *b*—Osteoporosis preceding tumor and produced by non-tumor cells.

an external tumor. Sometimes diffuse invasion occurs, followed by the appearance of a superficial tumor without extensive destruction of cortex. Erosion of cortex from the endosteal side may occur in primary peripheral sarcoma after the tumor has broken through one side and invaded the medullary canal, so that cortex opposite the point of onset may eventually be destroyed. The bone destruction in sarcoma is due largely to the osteoclastic action of tumor cells, as contrasted with carcinoma, where connective tissue cells produce most of the breaking down. Figure 21 shows bone absorption in round and spindle-celled peripheral sarcoma of the fibula, in which the osteoclasts are mainly tumor cells, and Figure 22 shows similar tumor cell absorption in a sarcoma of the humerus. Microscopic examination of bone about the limits of a spreading sarcoma sometimes shows marked osteoporosis, which is produced by non-tumorous fibroblasts and giant-celled osteoclasts, as at *b* in Figure 21. In some cases this may be very marked and extend to a distance of one or two centimeters away from the tumor, as in Figure 23, which is of the cortex located about one centimeter beyond the limits of the tumor shown in Figure 22. In round and spindle-celled sarcomas giant cells are frequent along the zone of absorption, and it is difficult to state whether or not they are neoplastic in origin.

New bone formation in the ossifying types of sarcoma may be sufficiently extensive to offset the reduction in density resulting from bone destruction, but its distribution and arrangement are usually such that the shadows cast are of diagnostic significance.

Central giant-celled tumors affecting the ends of the long bones form a special group, and it is still a question if they should be classified with sarcomas. They reduce bone density by eccentric growth and are entirely devoid of any tendency to undergo ossification. Erosion of the cancellous bone, and then of cortex, proceeds and may eventually lead to complete destruction of the surrounding

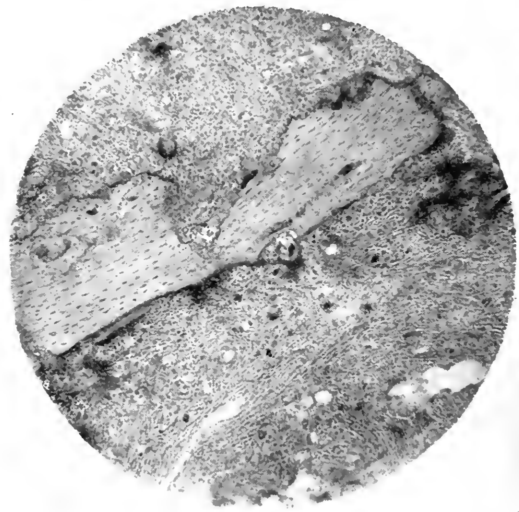

Fig. 22. Tumor-celled osteoclasts destroying cortex in sarcoma of humerus.

old bone. As this occurs, globular enlargement of the affected region is usually observed. In some instances the cortex is destroyed without associated periosteal new bone formation, and pathological fracture may result. In other cases, periosteal new bone formation occurs synchronously with

eccentric erosion by the tumor, so that a cortex of bone is maintained during the process of enlargement. Portions of the original cortex are rarely preserved in the expanded regions after the tumor has reached considerable size, but during the early stages they may be outwardly displaced and form

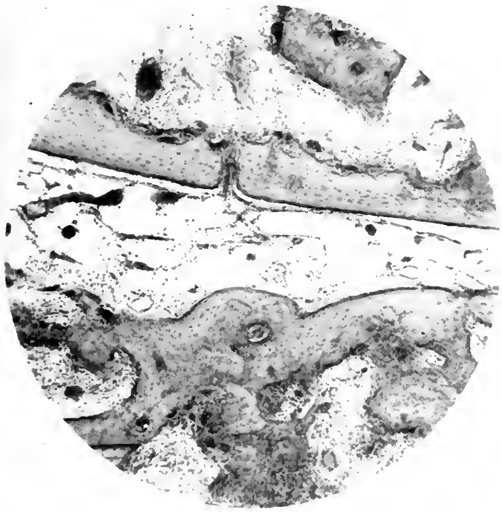

FIG. 23. Marked osteoporosis of portion of cortex, preceding spread of tumor in Figure 22.

part of the shell. Histologically these tumors consist of a groundwork of fibroblasts in various stages of maturation interspersed with a variable number of giant cells. There is considerable variation in vascularity. Mitotic figures and cell division are practically never seen, and the tumor has no microscopic appearances of malignancy. Bone erosion is produced largely by fibroblasts, there being no increase in the number of giant cells along the eroded surfaces above that contained in the interior of the tumor. The giant cells present along the periphery of the bone are of the type of osteoclasts seen in other destructive processes, while the giant cells of the tumor are frequently much larger and their cytoplasm may take a deeper acid stain. They are probably syncytial cells derived from the endothelium of the blood vessels. Figure 24 shows giant-celled tumor erosion of the cortex to the point of almost complete destruction without any new bone formation by the periosteum. Figure 25 shows enormous enlargement of the upper end of the humerus with the formation of an incomplete shell-like cortex by the periosteum as the interior destruction occurred. Figure 26 shows the process of peripheral new bone formation with slight destruction occurring from the inside. Note the small number of giant cells along the surface of bone about each tumor.

Bone absorption in benign tumors, as enchondromas and fibromas, is produced by fibroblasts and occasional giant-celled osteoclasts. The tumor cells exert no direct osteoclastic action.

Cysts.—In bone cysts the reduction in density is quite similar to that in giant-celled tumors, in that the process begins in the interior of the bone and produces eccentric erosion, without subsequent ossification of the tissue which caused the erosion. Aside from the fact that the cysts are more inclined to occur in younger individuals and to affect the shaft away from its ends, they also differ from giant-celled tumors in that extensive

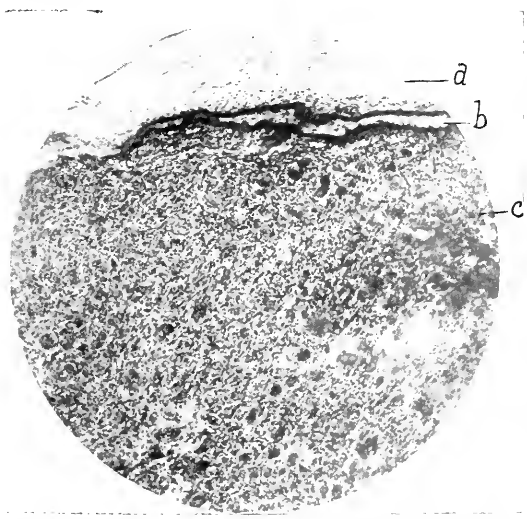

FIG. 24. Central giant-celled tumor erosion of cortex without periosteal new bone formation. *a*—Periosteum. *b*—Remnant of eroded cortex. *c*—Tumor. Note absence of tumor giant cells along surface of bone destruction.

destruction of cortex and marked enlargement of the involved region are rarely seen. However, small perforations of cortex are not uncommon, and secondary periosteal new bone formations may occur. Rarely cortex may be rapidly eroded and periosteum great-

FIG. 25. Central giant-celled tumor with shell formation. No ossification within the tumor. Trabeculae of cortical new bone.

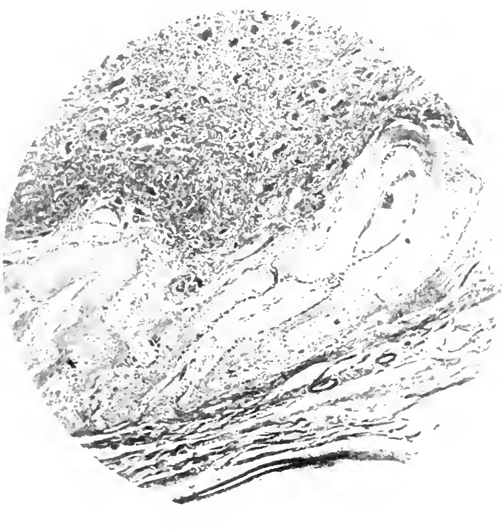

FIG. 26. Section of cortex in Figure 25, showing layer of periosteal new bone with tumor and destruction along its internal surface.

ly distended with marked enlargement of the part. Figure 27 shows a roentgenogram and Figure 28 the excised specimen of a large cyst of eight months' standing in the third metacarpal bone of a twenty-year-old woman, in which the cortex was extensively destroyed, periosteum greatly distended, and only a thin layer of new bone formed about its limits. The bone destruction occurs from within outward by the action of the cells of the fleshy lining of the cyst. Fibroblasts and giant-celled osteoclasts produce lacunar absorption along the surface and invade and dilate the haversian canals for some distance. Giant-celled activity is much more in evidence in the bone destruction of cysts than in that of giant-celled tumors. Figure 29 shows the destruction of old cortex and Figure 30 the structure of cyst wall in its thinnest portion in the last case with signs

of absorption from within outward. This specimen shows that breaking through of old or even of newly formed cortex is no criterion for distinction between giant-celled tumor and bone cyst. Trabeculation occurs in both cysts and giant-celled tumors, and

FIG. 27. Cyst of third metacarpal bone of nine months' duration in twenty-year-old woman. Cortex destroyed except at proximal end. Periosteum distended and has formed thin layer of bone about most of the periphery of cyst.

is peripheral in its location in both processes. It is due to the formation of shallow pockets from internal erosion and irregularly distributed new bone formation on the part of the periosteum.

Perthes' Disease.—The reduction in density in Perthes' disease is due to breaking down of the center of ossification in the epiphysis of the femoral head. This leads to secondary flattening of the head and to alterations in the shape of acetabulum and neck. In a case of nine months' standing (D. B. Phemister, "Operation for Epiphysitis of the Head of the Femur [Perthes' Disease]: Findings and Result." *Archives of Surgery*, March, 1921, Vol. II, p.221), in which there were roentgenological evidences of bone destruction with flattening and cavity and sequestrum formation, operation with excision of a window from the cartilage of the head revealed a broken-down center filled with soft tissue, which was partly necrotic, and with various-sized sequestra. Microscopic examination of the contents showed granulation tissue with evidences of active absorption in the sequestra and cartilaginous wall

FIG. 28. Specimen excised from case in Figure 27. *a*—Eroded cortex showing through window.

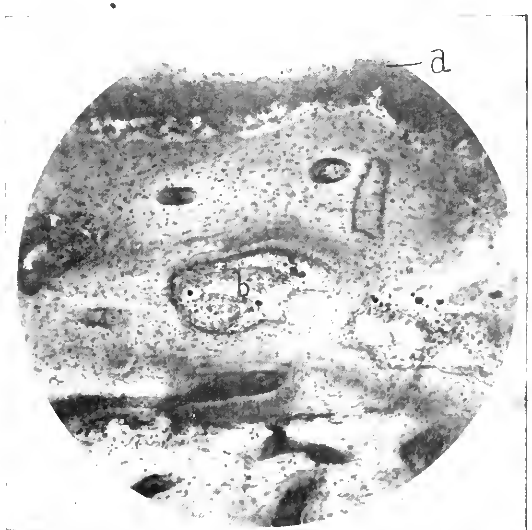

FIG. 29. Section of cortex in case in Figure 27. *a*—Lining of fibroblasts producing bone absorption. *b*—Haversian canals dilated by invading process.

(Fig. 31). Bacteriologic examination and guinea-pig inoculation were negative for micro-organisms, but grossly and microscopically the process resembled a quiescent focus of localized pyogenic infection of the bone. It is possible that the negative bacteriologic findings are to be accounted for by the duration of the process, as it is not uncommon to obtain negative cultures in cases of localized osteomyelitis of several months' standing.

Congenital Venous Aneurysm.—Figure 32 shows the roentgenologic appearance of the enlarged right upper extremity of an eighteen-year-old boy, produced by congenital venous aneurysm. The circular shadows, many of which are laminated, are produced by phleboliths that formed in the thrombi of the dilated vein. The humerus is little changed but the radius and ulna, in the region of which the varicosities are most marked, show extensive osteoporosis with longitudinal streaking and slight reduction in diameter. The cause of the osteoporosis is problematic. It is not due to disuse, as the function of the arm was not greatly impaired, and the humerus, which should be

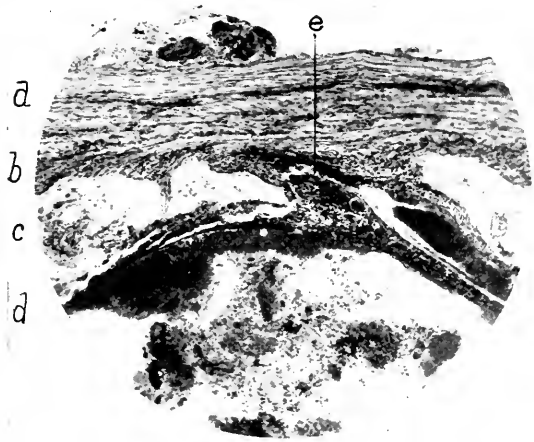

Fig. 30. Section of cyst wall in its thinnest portion. *a*—Fibrous layer of periosteum. *b*—Cambium layer. *c*—Thin layer of new bone. d—Cyst lining. Note perforation of bony layer at *c*, and extension of destructive cyst lining to fibrous layer of periosteum.

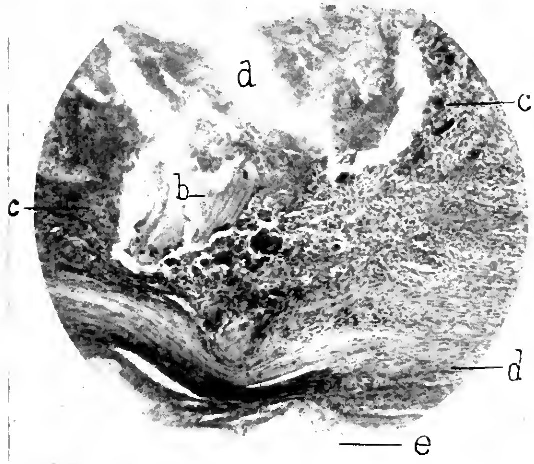

Fig. 31. Section through cartilaginous wall and inflammatory lining to cavity in epiphysis of head of femur in Perthes' disease. *a*—Necrotic contents. *b*—Sequestrum. *c*—Layer of granulations. *d*—Fibrous layer. *e*—Wall of cartilage.

Fig. 32. Congenital venous aneurysm of the upper extremity with marked osteoporosis of radius and ulna and circular shadows cast by phleboliths.

affected if this were the case, is practically free. It may be due to the venous congestion and consequent acidosis from an increase of the CO_2 content of the blood. This would augment the solubility of the lime salts and favor absorption. Similar osteoporosis has been observed in cases of enlargement of an extremity from congenital elephantiasis.

DISCUSSION

Answer to Dr. W. C. Hill. Gonorrheal infection of a joint produces rapid disappearance of the lime salts because of the marked loss of function resulting from the severe symptoms. The hyperemia and toxemia produced by the infection may possibly still further alter bone metabolism in such cases and exaggerate absorption of lime salts.

Answer to Dr. Geo. E. Pfahler. I believe Perthes' disease is an infectious process from the histologic examination of the excised tissue. The fact that cultures were negative does not exclude infection, because the process was of nine months' standing and it is not uncommon to obtain negative cultures of material removed from localized osteomyelitis several months after the onset.

Answer to Dr. H. K. Pancoast. In bone cyst the destruction occurs from within outward, and expansion of the bone is slight. It results from concomitant new bone formation on the part of the periosteum. The metacarpal cyst which I showed was an exception to this rule, in that considerable cortex was broken down and the cyst extended to the periosteum, partly dissecting the latter from the remaining bone and creating a large tumor. Pressure atrophy of bone in aneurysm is somewhat similar to that which occurs in tumors. Wherever bone is pressed upon, metaplasia of its connective tissue covering occurs, and osteoclasts are formed which lead to bone absorption in proportion to the amount of pressure.

Atrophy of bone following fracture is the result of disuse produced by the fracture, the immobilization for treatment, the muscle atrophy, joint stiffness, etc. Infection of the fracture increases the degree and duration of loss of function and consequently the amount of atrophy.

Answer to Dr. Percy Brown. I consider the atrophy in rheumatoid arthritis due to disuse.

Answer to Dr. W. R. Stewart. Roentgen signs are absent early in acute osteomyelitis, because bone destruction, being due to the action of infected tissue cells, does not occur to any appreciable extent until the acute destructive changes in the unossified tissue begin to subside and reparative changes set in. This requires from one to two weeks' time. It is difficult to state in a few words how to recognize the extent of dead bone in chronic osteomyelitis, and sometimes it cannot be done.[1] The greater density of dead bone, its irregular, sharp contour and the presence of a line of demarcation between the dead and living bone are the points of greatest assistance, but numerous factors, such as overlapping shadows of new and old bone and inflammatory changes in old or new bone, may lead to errors of diagnosis. It has been my experience that tumors that break through the cortex and lead to ossification extending into soft parts are malignant. However, benign processes, such as bone cyst, may completely erode the cortex and bulge beneath the periosteum without the occurrence of new bone formation about their periphery. In both of the cysts shown, old cortex had been completely eroded, in one very extensively, and in the other in two small places. I have never seen increase in the size and length of an extremity due to an angioma in the soft parts.

Answer to Dr. A. H. Pirie. A very small localized infection of bone, may in some instances leave an area of increased density, but this is not the case if an appreciable amount of bone destruction occurs.

Answer to Dr. L. R. Sante. Tuberculous osteomyelitis may affect the shaft of the bone, producing diffuse changes in the extremity difficult to differentiate from pyogenic osteomyelitis and syphilis by means of the x-ray.

Answer to Dr. B. C. Darling. I do not believe there is any distinction between osteomyelitis hemorrhagica of Barrie and central giant-celled tumors. There was no history of infection in the teeth or tonsils in this case of Perthes' disease.

[1]See "The Recognition of Dead Bone Based on Pathological and X-Ray Studies," D. B. Phemister, *Ann. Surg.*, October, 1920, lxxii, 467.

THE MAKING AND FILING OF RECORDS IN THE SECTION ON ROENTGENOLOGY IN THE MAYO CLINIC

By R. D. CARMAN, M.D.

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ROCHESTER, MINNESOTA

MANY inquiries from visitors to the Section on Roentgenology of the Clinic and letters requesting information concerning the method of keeping records in this department, led us to the conclusion that a description of the records might be of interest to a large number of the medical profession, more especially to those limiting their practice to roentgenology.

This method was evolved about eight years ago with the idea of covering every eventuality in order not only to learn the variations within normal limits but to learn the roentgen signs, both positive and negative. These records, accurately kept, together with a simple physiologic technique and abundant material controlled by operative and pathologic findings, added materially to our knowledge of both direct and indirect signs and have enabled us to bring our percentage of correct diagnoses to a very high degree of accuracy. Methods such as these have done much to place roentgenology at the head of the list of all methods of gastro-intestinal diagnosis. This is particularly true of the early lesions where the clinical data are usually indefinite. Too much stress connot be placed on the fact that the knowledge gained from studies of variations from the normal have been just as much a factor in this result as has been the study of the abnormal.

It has long been my conviction that progress in roentgen diagnosis lies along three very definite lines: ample material, full recording of all interpretations of this material, and careful comparison of those interpretations with surgical and pathologic findings. For many years in the Mayo clinic a complete record of the observations made on every patient sent for a gastro-intestinal study have been kept, irrespective of whether the findings were negative or positive. It is generally acknowledged that the fundamental requisite for a successful roentgenologist is a comprehensive knowledge of the normal. Our experience with these records has brought home the truth of this assertion. Equally important has been the inspection of the gross pathology presented at operation. The specimens have been followed to the laboratory and studied; comparisons have been made of the lesion as it appeared with the findings in the roentgenogram. Copies of the dictated notes on the operation have been made available to the department and these have been copied on to the statistical charts compiled from these records.

Record sheets similar to those used in the gastro-intestinal work have been made for the chest and the genito-urinary tract.

The test of any system is that it shall afford the maximum of accessibility to all information required, with the minimum expenditure of time and effort. This has been the aim in the evolution of this system. The record sheets all carry out this idea and are similar in many ways. They all bear the registration number, the name of the referring physician, the date, the name, age, and sex of the patient. Next follow the parts examined and a brief statement of the indication for examination. The line for the diagnosis is just above the printed key, in which the pathology is given a numerical code and the anatomy an alphabetical code unit. Thus, cancer of the stomach is written "5 B", duodenal ulcer "34 I". Incidentally the use of this code in the screen room makes it possible to discuss the screen findings without imparting any information to the patient. Sizes and degrees of density or involvement are expressed by numerals from 0 to 4, 4

representing the maximum. Code units of numerals or letters are used throughout the sheets and all units concerned in the study of a given case are underlined. The statistical charts are ruled and numbered to agree with the record sheets and in transferring the information to these charts the code units only are used (Fig. 1). The surgical findings in all cases in which operation is performed are copied on to the statistical charts. Records such as these always present the complete data on a given case in the same sequence and when transferred to the statistical charts they make a compact summary of roentgen signs in both the normal and the abnormal. Every patient admitted to the Clinic is given a registration card bearing a serial number (Fig. 2), the name and home address of the patient, the name of the chief of the section to which the patient is referred, the name of the examining physician, and the date of admission. This registration number is used on all the records of the patient throughout the Clinic, so that in time the record of an individual patient becomes complete in the general file of the Clinic and is there available for study and comparisons of the findings. Under a checking system these records are sent to various sections where they are wanted or may be assembled in the filing room for any given study.

All patients referred to the section of roentgenology from other sections are given a referring card (Fig. 3) with the name, registration number, the date, name of the referring physician and the section to which he is attached, the parts to be x-rayed, and a brief note of the information sought. The card is made in triplicate, the sheets being numbered 1, 2, and 3. Sheets 1 and 2 have carbon backs and the three separate sheets are filled out at one writing. The cards are enclosed in envelopes on which are printed and written all instructions for any necessary preliminary preparation and the time at which the patient is to come for examination.

The desk clerk asks for the registration card and as a check writes the registration number and age of the patient on the upper left hand corner, and notes whether the patient has been x-rayed in the section at any previous time. If so, the former record is taken from the files for comparison before the new report is made. If the patient has been x-rayed elsewhere recently an effort is made to determine the time elapsed and the amount of previous exposure in order to avoid any possible harm from overexposure.

The plate marker is made by the clerk who uses strips of 2 inch adhesive plaster cut in 2 inch lengths with the ends turned over to a depth of one-eighth of an inch. The date is put at the top of this oblong strip in quarter inch lead numerals and the registration number across the bottom in three-eighths inch lead numerals.

The marker is placed in the envelope with the referring card, all of which is sent with the patient to the technician.

The majority of our plates are marked in the upper left hand corner, the full set required for an individual case being marked at one exposure before the plates are exposed. They are protected while being marked with a sheet of lead soldered to galvanized iron, bound around the edges with adhesive tape and have an aperture just large enough to expose the marker (Fig. 4). An oblong of lead is attached by a brass clip over the marked area of each plate (Fig. 5). This is done to protect the mark during the exposure. Each technician carries a small aluminum plate to which his or her initials and the letters R and L in half-inch lead letters are fastened with adhesive. This is placed on the marker between the date and the registration number, thus marking every plate with the initials of the maker and indicating the right and left sides respectively. The initials of the operator are required in order to identify him with the case in the event of error, or necessary instruction in case of re-examination, or the need for special technique.

When the technicians have finished making the plates on any one patient the referring card and the marker are returned to the clerk. The markers are remade with new

registration numbers until their adhesive quality becomes so dull as to make them unfit for further use. The referring cards are then placed in racks beside the desk. Two of these racks have two rows of thirty pockets each for cards for the chest and the gastro-intestinal canal. A third rack of the same capacity has one row for cards for bones and one for cards of the urinary tract.

When the plates are dry they are brought to the plate room and sorted, the racks are brought in from the desk, and the plates are stacked with the referring card in front of each set, ready for interpretation.

The plates are filed in different colored envelopes according to the findings. Those with positive findings are filed in buff envelopes, some types with positive findings such as "heart enlarged," "phleboliths," etc., in blue envelopes, and the negative findings in yellow envelopes. A rack, mounted on rubber-tired wheels, with spaces for three sizes of each color envelope, is brought within easy reach of the one making the interpretations. The interpretations are dictated and typed, the plates are handed to the plate-room clerks with the envelopes in which they are to be filed, the same clerk receiving the referring card from the stenographer.

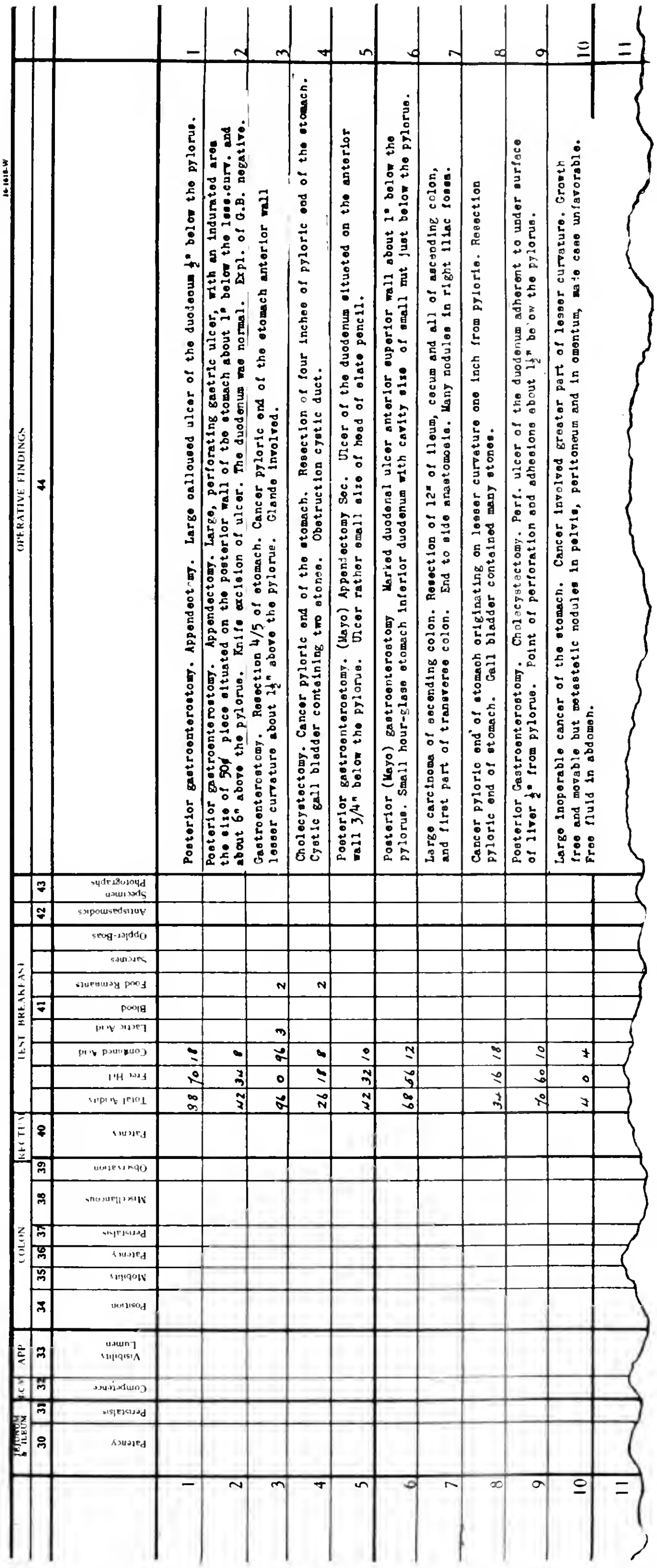
The number three sheet of the referring card is pasted on the upper right-hand corner of the envelope, the number one sheet is torn off and placed in the compartment bearing the number of the desk to which it will be sent later, and the number two sheet is placed in a compartment marked for the clerk in charge of records.

The plates are filed in numerical

SHEET A, PAGE 1   YEAR 1-1-21   DIGESTIVE TRACT SHEET, X-RAY   16-1617-W

	Case No. 1	Name 2	Age Sex	Parts Exam 3	Diagnosis 4	5 Extent Int	6 Confirmation	7 Habitus	Esophagus 8 Position	9 Patency	10 Peristalsis	Stomach 11 Tonus	12 Filling Defect	13 Form	14 Position	15 Size	16 Mobility	17 Peristalsis	18 Incisura	19 Evacuation	Pylorus 20 Position	21 Mobility	22 Patency	23 Opening	Duodenum 24 Visualization	25 Contour	26 Mobility	27 Patency	28 Peristalsis	29 Bulb	
1	144538	John Hutchings.	16M	S	Ulcer of the duodenum. Cap deformity.	x		n				o		f	n	2	2	1		c	n	2	f	l	y	n		f		d	1
2	144	J.D.Sweet.	38M	S	Perforating gastric ulcer.																										2
3	142065	R.E.Kamm.	48M	S	Cancer of stomach.Possible resectable.	x		n				o	pdl	f	n	2	2	0		n3c	n	2	om	n	o					o	3
4	142517	T.B.Wright	63M	S	Lesion at the pylorus	x		n				o	p	f	n	3	2	1		n2l	n	2	pm	d	y	n		f		n	4
5	142853	J.C.Kenner	42M	S	Ulcer of the duodenum.	i		n				h		f	n	2	2	3		c	n	2	f	l	y	n		f		d	5
6	143989	M.Rose	42M	S	Ulcer of the duodenum.							h		f	n	2	2	1		c	n	2	f	l	y	n		f			6
7	144469	Henry Wahl	50M	C	Cancer ascending colon.																										7
8	147794	Mrs.E.D.Mattson	45F	S	Cancer of the stomach.Operable.	x		e				o	p	f	n	2	2	1		n2l	n		om		y	r		f		n	8
9	148257	Mrs. J.R.Miser	55F	S	Ulcer of the duodenum.	x		e				o		f	n	2	2	3		c	n	2	f	l	y					d 2	9
10	154877	Chris Larson	48M	S	Cancer stomach.Operability doubtful.	x		n				o	mp	f	n	3	2	1		nlc	n	2	os	d	y	y	n	f		n	10
11																															11

FIG. 1. Recapitulation chart.



DIGESTIVE TRACT SHEET, X-RAY SHEET B, PAGE 1 YEAR 1-1-21

	Total Acidity	Free HCl	Combined Acid	Lactic Acid	Food Remains	Operative Findings
1	38	70	18			Posterior gastroenterostomy. Appendectomy. Large calloused ulcer of the duodenum ½" below the pylorus.
2	42	34	8			Posterior gastroenterostomy. Appendectomy. Large, perforating gastric ulcer, with an indurated area the size of 50¢ piece situated on the posterior wall of the stomach about 1" below the less.curv. and about 6" above the pylorus. Knife excision of ulcer. The duodenum was normal. Expl. of G.B. negative.
3	96	0	96	3	2	Gastroenterostomy. Resection 4/5 of stomach. Cancer pyloric end of the stomach anterior wall lesser curvature about 1½" above the pylorus. Glands involved.
4	26	18	8		2	Cholecystectomy. Cancer pyloric end of the stomach. Resection of four inches of pyloric end of the stomach. Cystic gall bladder containing two stones. Obstruction cystic duct.
5	42	32	10			Posterior gastroenterostomy. (Mayo) Appendectomy Sec. Ulcer of the duodenum situated on the anterior wall 3/4" below the pylorus. Ulcer rather small size of head of slate pencil.
6	68	56	12			Posterior (Mayo) gastroenterostomy. Marked duodenal ulcer anterior superior wall about 1" below the pylorus. Small hour-glass stomach inferior duodenum with cavity size of small nut just below the pylorus.
7						Large carcinoma of ascending colon. Resection of 12" of ileum, cecum and all of ascending colon, and first part of transverse colon. End to side anastomosis. Many nodules in right iliac fossa.
8	34	16	18			Cancer pyloric end of stomach originating on lesser curvature one inch from pyloric. Resection pyloric end of stomach. Gall bladder contained many stones.
9	70	60	10			Posterior Gastroenterostomy. Cholecystectomy. Perf. ulcer of the duodenum adherent to under surface of liver ½" from pylorus. Point of perforation and adhesions about 1½" below the pylorus.
10	4	0	4			Large inoperable cancer of the stomach. Cancer involved greater part of lesser curvature. Growth free and movable but metastatic nodules in pelvis, peritoneum and in omentum, male case unfavorable. Free fluid in abdomen.
11						

Fig. 1. Recapitulation chart.

order, the positive at one end of the plate-room and the negative at the other. The 14 inch by 17 inch plates are in one series of compartments and all other sizes in another series. The envelopes are placed on edge with the labeled upper right-hand corner in front and one compartment is allowed for every one hundred registration numbers in each size. This arrangement enables us to keep plates with positive findings in the file room for about six months. At the end of this period they are culled of all that suggests no further clinical interest and transferred to permanent files in another part of the building. All plates in blue envelopes are discarded at this time. Negative plates (in yellow envelopes) are discarded at the end of thirty days.

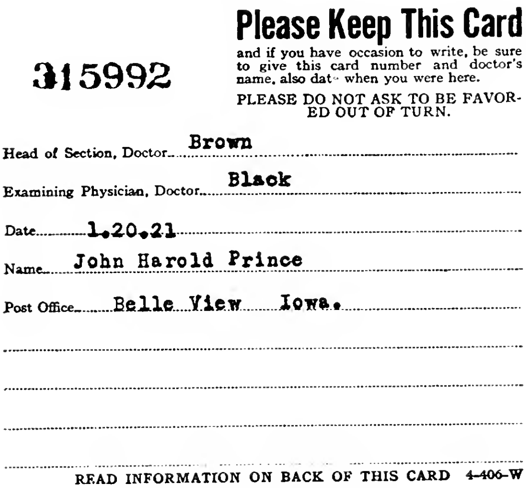
Plates showing conditions of unusual interest or findings that give them a value for teaching purposes are sent for reduction on 5 inch by 7 inch films from which lantern slides are made later. When reductions and lantern slides have been made the original plates are discarded.

The reductions are filed in numerical order in envelopes on which the registration number is stamped and the name of the patient and clinical or surgical findings are typed.

The lantern slides are filed in envelopes similarly marked, but instead of being in numerical order they are grouped according to pathologic interest.

We have found that it adds to the value of the lantern-slide file to cross index by carrying cards of the same size as the envelope in such cases as syphilis of the stomach, with hour-glass contrac-

tions. In such cases the envelope is carried under syphilis of the stomach, while the card bearing the same number and information is carried under hour-glass stomach. This obviates the necessity of any index for the reductions or the lantern slides.


Please Keep This Card

315992

and if you have occasion to write, be sure to give this card number and doctor's name, also date when you were here.

PLEASE DO NOT ASK TO BE FAVORED OUT OF TURN.

Head of Section, Doctor Brown

Examining Physician, Doctor Black

Date 1.20.21

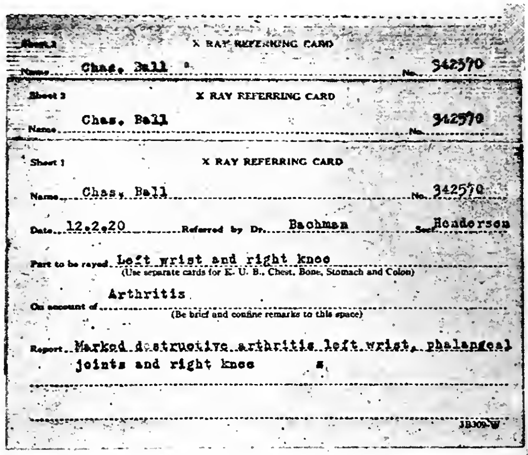
Name John Harold Prince

Post Office Belle View Iowa.

READ INFORMATION ON BACK OF THIS CARD 4-406-W

Fig. 2. Registration card.

We use the ordinary unit-type filing cabinet, the reductions in files with drawers for 8 inch by 5 inch cards, and the lantern slides in drawers for 5 inch by 3 inch cards. The No. 1 sheet of the referring card is returned to the physician when the interpretation has been made. The No. 2 sheet is given to the clerk in charge of records and department records are made from it. The negative cases are entered on a sheet headed "———Sheet,


Sheet 3 X RAY REFERRING CARD

Name Chas. Ball No. 342570

Sheet 2 X RAY REFERRING CARD

Name Chas. Ball No. 342570

Sheet 1 X RAY REFERRING CARD

Name Chas. Ball No. 342570

Date 12.2.20 Referred by Dr. Bachman Sec. Henderson

Part to be rayed left wrist and right knee
(Use separate cards for K. U. B., Chest, Bone, Stomach and Colon)

On account of Arthritis
(Be brief and confine remarks to this space)

Report Marked destructive arthritis left wrist, phalangeal joints and right knee

Fig. 3. Referring card.

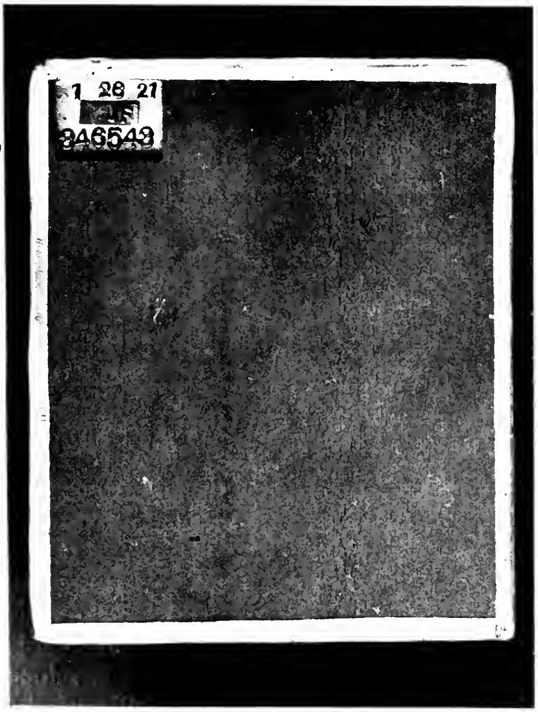


Fig. 4. Lead plate shield with plate marker in place.

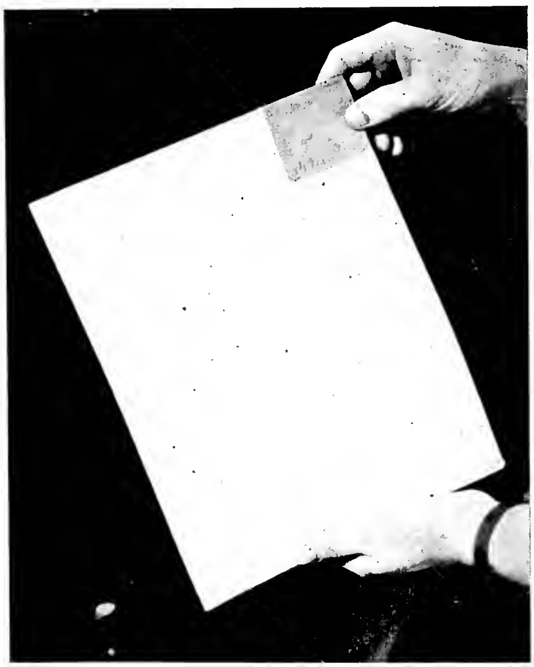


Fig. 5. Brass clip to protect plate marker during exposure.

346000-347000 Chest SHEET, X-RAY
Mayo Clinic

Case Number Negative Findings

1/11/21 346006MT	1/15/21 346069MT	1/18/21 346625MT	1/19/21 346501MT	1/20/21 346996M			
346045MT	346101MT	346604MT	346696MT	346896M			
346019MT	346122MT	346595M	346698M	346864M			
346016 S	346186MT	346582M	346774MT	346960MT			
346012MT	346191MT	346578 S	346755 S	346929MT			
346009MT	346271MT	346562M	346726MT	346840M			
346120MT	346279MT	346537 S	346716 S	346817MT			
1/12/21 346080MT	346285MT	346495MT	346714 S	346799MT			
346059MT	346329MT	346420MT	346690 S				
346027MT	1/16/21 346577 S	346228MT	346683MT				
346000MT	346521 S	346202MT	346677MT				
1/13/21 346183MT	346509 S	346188 S	346673MT				
346148M	346503 S	346724MT	346667MT				
346172MT	346483 S	346680MT	346653MT				
346168MT	346480 S	346675M	346155MT				
346110MT	346466 S	346652M	1/20/21 346912 S				

Fig. 6. History sheet on which are recorded negative findings.

HISTORY SHEET, X-RAY
MAYO CLINIC

NO. PLATES .... SIZE (8, 10, 11, 14) ....

Case No. A 347038 *X-Ray No.* .... *Phy.* Moore *Date* 1-21-21

NAME P. N. Miller ADDRESS .... SEX (m. f.) AGE 64

INDICATIONS FOR EXAMINATION ....

ADDITIONAL RADIOGRAMS ....

PARTS EXAMINED Left knee and tibia.

DIAGNOSIS Old fracture of the patella with firm union. Marked destructive arthritis of the knee.
Areas of calcification in soft tissues posteriorly. M.

SUBSEQUENT EXAMINATIONS ....

Fig. 7. History sheet, x-ray, for recording lesions of the osseous system.

x-ray, Case number, Negative findings" (Fig. 6). The blank is filled in to correspond with the headings of the different department record sheets. Separate sheets are used for "Digestive tract," "Chest," "Bone," "Urinary tract," etc. One sheet is headed for each thousand registration numbers and the date, registration number, and initials of the physician making the interpretation are entered for each negative case. All the sheets for each 5,000 registration numbers are kept in slip covers on which is stamped the open-

CHEST SHEET, X-RAY

1. CASE NO. A.. .... 2. X-RAY NO............. ....Phy......... ....Date................................
3. NAME..Sex, (m. f.).. ....Age ....Size of Patient 1 2 3..............................
4. INDICATION FOR EXAMINATION ADDITIONAL RADIOGRAPHS
5. CONFIRMATION Confirmed by.....................Contradicted by........... ....Bacteriologic.....................Operation........... ......P. M.

KEY—?Possible pProbable dDefinite rRight lLeft uUpper mMiddle oLower aApex hHilus bBase fAnterior kPosterior Size or Degree 0, 1, 2, 3

CHEST 6. Expansion—eEqual nUnequal xDiminished R L 7. Density R 0 1 2 3 gGeneral cLocal u m o / L 0 1 2 3 gGeneral cLocal u m o

PLEURA 8. Density R 0 1 2 3 gGeneral cLocal u m o / L 0 1 2 3 gGeneral cLocal u m o 9. nRetraction R L

LUNG 10. Bronchus—Density R 0 1 2 3 / L 0 1 2 3 11. Fibrillation R 0 1 2 3 u m o / L 0 1 2 3 u m o

12. Consolidation R 1 2 3 gGeneral cLocal u m o xSingle yMultiple zSize 1 2 3 / L 1 2 3 gGeneral cLocal u m o xSingle yMultiple zSize 1 2 3

13. Congestion R 1 2 3 xActive yPassive u m o / L 1 2 3 xActive yPassive u m o 14. Glands R 1 2 3 xSingle yMultiple / L 1 2 3 xSingle yMultiple

15. Cavity Size R 1 2 3 xSingle yMultiple u m o / L 1 2 3 xSingle yMultiple u m o

HEART 16. Size—0 1 2 3 xAuricular enlargement yVentricular enlargement

17. Position—nNormal qTransposed gDisplaced rRight 1 2 3 lLeft 1 2 3 eUp 1 2 3 wDown 1 2 3 vVertical xTransverse

18. Pericardial Sac—sSize 0 1 2 3 xDensity 0 1 2 3 Outline—yRegular zIrregular cCardio-hepatic angle 0 1 2 3

AORTA 19. Size—0 1 2 3 gGeneral cAscending nArch eDescending xFusiform yPulsatile zExpansile

20. Position—nNormal gDisplaced 1 2 3 rRight lLeft fAnteriorly kPosteriorly

21. Retrocardiac Space Diminished 1 2 3 22. Esophageal Obstruction 1 2 3

MEDIASTINUM 23. Density—gDegree 0 1 2 3 nSize 1 2 3 Location u m o f k wCircumscribed xDiffuse yRegular zIrregular

DIAPHRAGM 24. Excursion R nNormal iIncreased yDiminished zAbsent / L nNormal iIncreased yDiminished zAbsent

25. Position R nNormal yHigh zLow / L nNormal yHigh zLow

26. Contour—yRegular zIrregular wBroken

7-704-W

KEY—?Possible pProbable dDefinite rRight lLeft uUpper mMiddle oLower aApex hHilus bBase fAnterior kPosterior Size or Degree 0, 1, 2, 3

LUNG

28. Abscess.............
29. Anthracosis........
30. Asthma............
31. Atele..............
32. Bronchiectasis.....
33. Bronchitis..........
34. Congestion ....
35. Consolidation......
36. Emphysema ......
37. Fibrosis............
38. Foreign Body......
    wBronchus yTrachea
    xLung zEsophagus
39. Malignancy.........
    yPrimary.............
    zMetastatic ....
40. Syphilis.. ....
    yInfiltration..........
    zGummata........ ....
41. Tuberculosis.......
    cCavity ....
    jDiffuse..............
    vEarly ....
    wHealed (Calcified)...
    xInfiltration..........
    yMiliary... ....
    zOld...................
42. Tumor ....
    vBenign..............
    wMalignant ....
    xCystic...............
    yPrimary ....
    zMetastatic...........

PLEURA

43. Fistula (Thoracotomy)
44. Fluid in... .. ...
45. Foreign Body. ....
46. Pleuritis...... ..
    xInterlobular. . . .
    yPeripheral (thick'n'd)
    zTubercular ... ..
47. Tumor.. . ...

MEDIASTINUM

48. Abscess...........
49. Adenitis......... .
    wInflammatory.. ....
    xHodgkins' Disease..
    yMalignant...........
    zTubercular.........
50. Aneurysm.. .
    cAscending ..
    eArch. .. .. .
    gDescending.....
    iInnominate...... .
    jSubclavian . .
    qCarotid. ... .
51. Aortic Dilatation
    xAscending . .. ..
    yArch........ ....
    zDescending... ....
52. Goiter, Substernal..
53. Goiter, Superficial.
54. Mediastinitis.......
55. Thymus...........
    yEnlarged.. ....
    zPersistent...... .. .
56. Trachea. .. . ...
    yDisplaced . ...
57. Tumor ....
    xBenign. .. . .
    yMalignant. .. . ..
    zCystic.. .. ..

HEART

58. Displacement, R L
59. Enlargement.....
60. Pericardial Adhesions.. ....
61. Pericardial Fluid...
62. Transposed........
63. Transverse........
64. Vertical............

NEGATIVE—

DIAGNOSIS— *T. B. both uppers, marked fibrosis in the left upper. S.*

FIG. 8. Chest sheet, *x*-ray.

ing and closing number of the series contained. The negative sheets are filed in separate drawers in the department record file.

The department records are made out on the sheets described earlier, four different forms being used, headed respectively "History sheet, *x*-ray" (Fig. 7), "Chest sheet, *x*-ray" (Fig. 8), "Urinary tract sheet, *x*-ray" (Fig. 9) and "Digestive tract sheet, *x*-ray" (Fig. 10).

In the gastro-intestinal examinations a "fluoroscopic sheet, *x*-ray" (Fig. 11) is

URINARY TRACT SHEET, X-RAY
MAYO CLINIC

1. CASE NO. A 346555 2. X-RAY NO............PHY. Moore DATE 1-18-21 NO. PLATES....SIZE (8, 10, 11, 14)...
3. NAME Thomas Ash Sex, (m. f.)........Age 35 Address....................
4. LAST PREVIOUS RAYING OF PATIENT.................... 5. ADDITIONAL RADIOGRAPHS....................
6. PARTS EXAMINED—kKidney uUreter bBladder sProstate uUrethra aAll
7. CLINICAL DIAGNOSIS (or data).................... ?Possible pProbable dDefinite
8. DIAGNOSIS 1....Anomaly.......... 2....Cyst.......... 3....Displacement.......... 4....Diverticulum..........
5....Foreign body....... 6....Hydronephrosis.......... 7....Hydroureter....... 8....Indeterminate..........
9....Normal.......... 10....Obstruction.......... 11....Pyelitis.......... 12....Pyonephrosis..........
13....Pyoureter.......... 14....Stone.......... 15....Tuberculosis....... 16....Tumor.......iInt....eExt...
kKidney uUreter bBladder sProstate uUrethra
9. EXTENT OF INTEREST oOrdinary iInteresting xExtraordinary
Findings: Phleboliths on both sides. Small shadow over left kidney. Probably not stone. M.
write in full as reported to clinician

10. AGREEMENT AND CONFIRMATION aAgrees with clinical dDisagrees pPartially confirmed cConfirmed nContradicted by tTreatment results oOperative Findings mPost Mortem 1 Small 2 Medium 3 Large

PREPARATION OF PATIENT—gGood fFair pPoor sSize of Patient (1, 2, 3)........

RADIOGRAPHY

RIGHT KIDNEY
11. VISIBILITY OF OUTLINE vVisible iInvisible
12. SIZE (1, 2, 3)..........Shape. nNormal iIrregular
13. POSITION nNormal dDisplaced to rRight lLeft oRotated yLow Lying, degree (1, 2, 3)..........pPelvic
14. SHADOWS (Suspicious) iSingle mMultiple
15. SHADOWS (Extrarenal) iSingle mMultiple Due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis cCalcified Areas or Glands rCalcified Costal Cart gGallstone tFract. Transverse Process

LEFT KIDNEY
16. VISIBILITY OF OUTLINE vVisible iInvisible
17. SIZE (1, 2, 3)..........Shape. nNormal iIrregular
18. POSITION nNormal dDisplaced to rRight lLeft oRotated yLow Lying, degree (1, 2, 3)..........pPelvic
19. SHADOWS (Suspicious) iSingle mMultiple
20. SHADOWS (Extrarenal) iSingle mMultiple Due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis cCalcified Areas or Glands rCalcified Costal Cart gGallstone tFract Transverse Process

RIGHT URETER
21. SHADOWS aSuspicious eExtraureteral

LEFT URETER
22. SHADOWS sSuspicious eExtraureteral

BLADDER
23. SHADOWS sSuspicious eExtravescial

PYELOGRAPHY

DATE....................

RIGHT KIDNEY
24. VISIBILITY OF OUTLINE vVisible iInvisible
25. SIZE (1, 2, 3)..........Shape. nNormal iIrregular
26. POSITION nNormal dDisplaced to rRight lLeft oRotated yLow Lying, degree (1, 2, 3)..........pPelvic
27. SHADOWS (Intrarenal) pPelvic kCortical iSingle mMultiple Size (1, 2, 3).......vVarious Due to sStone tCalcified Areas yCyst uTumor, intrinsic cCaseous Areas (Tuberculosis)
28. SHADOWS (Extrarenal) iSingle mMultiple Due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis bCalcified Areas or Glands rCalcified Costal Cart gGallstone tFractured Transv. Process
29. HYDRONEPHROSIS Size (1, 2, 3)..........fInfectious oObstructive
30. PYONEPHROSIS Size (1, 2, 3)..........tTubercular nNon-Tubercular
31. PYELITIS sSlight mMarked
32. ANOMALIES fFused hHorseshoe sSolitary rReduplication pelvis

LEFT KIDNEY
33. VISIBILITY OF OUTLINE vVisible iInvisible
34. SIZE (1, 2, 3)..........Shape. nNormal iIrregular
35. POSITION nNormal dDisplaced to rRight lLeft oRotated yLow Lying, degree (1, 2, 3)..........pPelvic
36. SHADOWS (Intrarenal) pPelvic kCortical iSingle mMultiple Size (1, 2, 3).......vVarious Due to sStone tCalcified Areas yCyst uTumor, intrinsic cCaseous Areas (Tuberculosis)
37. SHADOWS (Extrarenal) iSingle mMultiple Due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis cCalcified Areas or Glands rCalcified Costal Cart gGallstone tFractured Transv Process
38. HYDRONEPHROSIS Size (1, 2, 3)..........fInfectious oObstructive
39. PYONEPHROSIS Size (1, 2, 3)..........tTubercular nNon-Tubercular
40. PYELITIS sSlight mMarked
41. ANOMALIES fFused hHorseshoe sSolitary rReduplication pelvis

10-1007 W

FIG. 9. Urinary tract sheet, *x*-ray (*front*).

RIGHT URETER

42. SHAPE nNormal tTortuous
43. POSITION nNormal dDisplaced to rRight lLeft
44. PATENCY fFree dDilated locally at .... {1 2 3} aThroughout oObstructed at ..... {1 2 3} by sStone rStricture kKink tTumor
45. SHADOWS (Intraureteral) sStone gSingle tMultiple Size lLarge mMedium aSmall vVarious oLocation .... {1 2 3}
Shape rRegular iIrregular
46. SHADOWS (Extraureteral) due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis
cCalcified Areas or Glands rCalcified Costal Cart tFract Transv. Proc
47. ANOMALIES rReduplication cComplete pPartial. Location ..... {1 2 3} dDiverticulum Location .... {1 2 3}

LEFT URETER

48. SHAPE nNormal tTortuous
49. POSITION nNormal dDisplaced to rRight lLeft
50. PATENCY fFree dDilated locally at .... {1 2 3} aThroughout oObstructed at .... {1 2 3} by sStone rStricture kKink tTumor
51. SHADOWS (Intraureteral) sStone gSingle tMultiple Size lLarge mMedium aSmall vVarious oLocation .... {1 2 3}
Shape rRegular iIrregular
52. SHADOWS (Extraureteral) due to bBowel Contents sSkin Conditions aAtheroma pPhleboliths eExostosis
cCalcified Areas or Glands rCalcified Costal Cart tFract. Transv. Proc.
53. ANOMALIES rReduplication cComplete pPartial. Location .... {1 2 3} dDiverticulum Location ...... {1 2 3}

BLADDER

54. SIZE dDilated cContracted
55. SHAPE rRegular iIrregular
56. POSITION nNormal dDisplaced rRight lLeft
57. SHADOWS (Intravesical) sStone gSingle tMultiple Size lLarge mMedium aSmall fForeign Body dDiverticulum
uTumor (intrinsic) pPhosphatic deposit in wall

PROSTATE

58. sStone iSingle mMultiple hHypertrophy tTumor

URETHRA

59. sStone fForeign Body

REMARKS·

FIG. 9. Urinary tract sheet, *x*-ray (*back*).

added to the data sent in with the patient and in all re-ray cases the former records of the patient are also sent in. The screen findings are recorded on the fluoroscopic sheet, the words and numbers concerned are underlined, and the diagnostic opinion is recorded in the blank rectangular space. All these findings are compared with the plate interpretation, The diagnosis is dictated and typed on the referring card and the procedure from this point is the same as heretofore described.

The positive records are all filed together in numerical order; if more than one record exists on one patient they are clipped together. Guide cards divide the records of every five hundred registration numbers.

The findings are indexed and cross indexed, the main divisions anatomic and the subdivisions pathologic. Different colored guide charts are used in the divisions and the subdivisions, one color denoting anatomic and another pathologic divisions or subdivisions.

If in interpreting plates we find some that promise unusual interest the registration number is noted and later these plates are put into the lantern slide compartment for the investigation of the history of the patient and the making of lantern slides if they are deemed sufficiently interesting.

Copies of the dictated notes on all necropsies are sent to the section and the plates on all are brought to the lantern slide compartment for investigation and study.

In the working out of this system we have had valuable suggestions from visitors to the Clinic and from clinics we have visited. The system has proved satisfactory in the Section of Roentgenology of the Mayo Clinic in recording the findings in more than 57,000 examinations made in 1920. The simplicity of the system makes it applicable to departments in hospitals or clinics or even a large private practice.

DIGESTIVE TRACT SHEET, X-RAY.
MAYO CLINIC

N. P.

1. Case No. A 154877 Phy Parker (C Logan) Date 1-1-21 NO. PLATE ____ SIZE ____ 8, 10, 11, 14 ______
2. NAME Chris Larson Sex, M. F. M. Age 48 Address New York
3. PART EXAMINED—eEsophagus sStomach dDuodenum iSmall Intestine cColon rRectum gGall-bladder hStasis aAll

Clinical Data ______

NOTE—Under column 4 (Diagnosis) numbers 1 to 38 represent lesions, and the letters A to U, anatomical parts involved. A diagnosis would be recorded thus: Cancer of the stomach, "5 B"; Ulcer of the duodenum "34 I"; etc.

4. DIAGNOSIS ______

(1)Abscess (2)Adhesion (3)Anomaly (4)Atony (5)Cancer (6)Dilatation (7)Displacement (8)Diverticulum
(9)Enteroptosis (10)Fistula (11)Foreign Body (12)Hernia diaphr. (13)Hirschsprung's Dis. (14)Hour-Glass
(15)Incompetence (16)Indeterminate (17)Jackson's M. (18)Kink (19)Negative (20)Non-Rotation
(21)Normal (22)Obstruction (23)Ptosis (24)Redundancy (25)Spasm (26)Spasticity (27)Stasis
(28)Stenosis (29)Stricture (30)Syphilis (31)Transposition (32)Tuberculosis (33)Tumor (34)Ulcer
(35)Cardiospasm (36)Gall-stones (37)Filling Defect (38)Diverticulitis (39)Chr. Ulc. Colitis

(A)Esophagus (B)Stomach (C)Cardia (D)Media (E)Pars pylor. (F)Pylorus
(G)Greater curv. (H)Lesser curv. (I)Duodenum (J)Jejunum (K)Ileum (L)Ileo-cecal Valve
(M)Colon (N)Cecum (O)Ascending Colon (P)Hepatic Flexure (Q)Transverse Colon
(R)Splenic Flexure (S)Descending Colon (T)Sigmoid Flexure (U)Rectum

FINDINGS Cancer of the stomach, Operability doubtful
(as reported, write in full)

5. **EXTENT OF INTEREST**—oOrdinary iInteresting xExtraordinary
6. **CONFIRMATION**—Partially confirmed by cConfirmed by nContradicted by tTreatment results oOperative Findings mPost-Mortem
7. **HABITUS**—nNormal eEnteroptotic

ESOPHAGUS
8. **POSITION**—nNormal dDisplaced rRt. lLt. fFwd. bBack
9. **PATENCY**—fFree dDilated uUpper mMiddle wLower oObstructed degree (1 2 3 4)____sSymmetrical yIrregular uUpper mMid. wLower xDiverticulum, apparent size (1 2 3 4)______aAnt. pPost. rRight lLeft At level of__________vertebra
(0. Not Seen, 1. Normal, 2. Active 3. Vigorous)
10. **PERISTALSIS**—(0 1 2 3)______tAntiperistalsis

STOMACH
11. **TONUS**—hHypertonic oOrthotonic yHypotonic
12. **FILLING DEFECTS**—cCard mMed. pPyl. gGreater curv. lLesser curv. nAnterior wall sPosterior wall tCentral wNiche kAcc. Pocket
13. **FORM**—fFish-hook sSteer-horn hHour-glass oOrganic pSpasmodic dDeformed
14. **POSITION**—nNormal vVertical oOblique tTransverse Displaced rRt. lLt. uUp dDown zTransposition sHernia (diaph.)
(1. Small 2. Medium, 3. Large, 4. Very Large.)
15. **SIZE**—(1 2 3 4)________
(0. Fixed, 1. Slightly Mobile, 2. Mobile)
16. **MOBILITY**—(0 1 2)______
(0. Not Seen, 1. Normal, 2. Active, 3. Hyperperistalsis)
17. **PERISTALSIS**—(0 1 2 3)______tAntiperistalsis yIrregular
18. **INCISURA**—cCard. mMed. pPyl. nNarrow bBroad dDeep sShallow =Double †Multiple uPseudo tTransient yCorresponds to pain pt
19. **EVACUATION**—(c)Complete after six hrs. nIncomplete after six hrs. Size of Residue (1 2 3 4)______hHead_____

PYLORUS
20. **POSITION**—nNorm. Displaced rRt. lLt. uUp. oDown.
(0. Fixed, 1 Slightly Mobile, 2. Mobile.)
21. **MOBILITY**—(0 1 2)________
22. **PATENCY**—fFree gGaping oObstructed sSlightly mMkd.
23. **OPENING**—iImmediate dDelayed nNot Seen

DUODENUM
24. **VISUALIZATION**—yVisualized oNot Visualized
25. **CONTOUR**—rRegular yIrregular dDiverticulum bBulb 2Second Portion 3Third Portion
26. **EVACUATION**—nNormal rRapid tSlow 6 Hour Residue (1 2 3 4)______
27. **PATENCY**—fFree dDilated oObstructed sSlightly mMkd.
(0. Not Seen, 1. Normal, 2. Active, 3. Vigorous)
28. **PERISTALSIS**—(0 1 2 3)______
29. **BULB**—nRegular dDeformed Size__(1 2 3 4)___________oNot Seen

10-1000 W

FIG. 10. Digestive tract sheet, *x*-ray (*front*).

JEJUNUM AND ILEUM 30. PATENCY—nNorm dDilated........oObstructed........kKink aAdhesion tTumor bForeign Body fFistula vDiverticulum sStasis after........hrs.

31. PERISTALSIS—nNorm rRapid sSlow fFrequent iInfrequent

ILEO-CECAL VALVE 32. COMPETENCE—iIncompetent oObstructed

APPENDIX 33. VISIBILITY—vVisible dTender aFixed bRetrocecal

LUMEN—nNorm wWide rNarrow tTortuous cCurled kKinked fFistula

(To indicate part of bowel affected enter on the dotted line after the item the following letters) (C, A, H F, T, S F, D. S)

COLON 34. POSITION—nNormal........dDisplaced........rRt........lLt........uUp........wDown..........zNon-rotation..........zTransposition

35. MOBILITY—0 Fixed..........1 Slightly Mobile..........2 Mobile..........

36. PATENCY—nNormal lDilated..........oObstructed..........

37. PERISTALSIS—aAntiperistalsis......nNormal......oNot Seen......

38. MISCELLANEOUS—vDiverticulitis..........uFistula..........jAdhesions............rRedundancy............zFilling Defect.............

aAnomaly..........bForeign Body..........kStasis..........cColitis..........After hrs......

39. OBSERVATION—after jInjection gIngestion

RECTUM 40. PATENCY—fFree dDilated oObstructed iImpaction tTumor bForeign Body aAdhesions fFistula

41. TEST BREAKFAST—Chemical; tTotal Acidity..........fFree Hcl..........cCombined Acidity..........lLactic Acid..........Microscopic:

bBlood..........rFood Remnants..........sSarcinae..........yYeast Cells..........

42. ANTISPASMODIC GIVEN—bBelladonna aAtropine pPapaverine

43. SPECIMEN PHOTOGRAPHS—yYes nNo

44. OPERATIVE FINDINGS:

Fig. 10. Digestive tract sheet, *x*-ray (*back*).

FLUOROSCOPIC SHEET 10-1008-W

MAYO CLINIC

Case No. A.................... Sex.................... Age.................... Date....................

Name..

Chemical { Total Acidity / Free HCl. / Comb. Acids / Lactic Acid

Microscopic { Food Remnants / Oppler-Boas / Yeast / Sarcines

4

N. P.

34 I

C

Habitus	Hypersthenic	~~Asthenic~~	Sthenic			
Residue	0.	1.	2.	3.	4.	
Head	~~L.~~	C.	H. F.	T. C.	S. F.	D.	S.
Peristalsis	Nor.	Active	~~Vigorous~~	~~Hyper.~~	Not Seen	
Bulb	~~Seen~~	Regular	~~Irregular~~	Not Seen		
Duod. Visualized	Immediately	Delayed	Not Seen			
Antrum	Seen	~~Regular~~	Irregular	Not Seen		
Mobility	~~Free~~	Slightly Fixed	Fixed			
Tender Point	L. C.	Doud.	G. B.	McB.	Epig.	
Filling Defects	Cardia	Media.	Pylorica	GC.	LC.	
Niche						
Accessory Pocket						
Incisura	Cardia	Media.	Pylorica	Transient		
Diverticulum						
Hour-Glass Stomach	Organic	Spasmodic	Intermittent			
Operations:						

Fig. 11. Fluoroscopic sheet.

CONGENITAL NON-ROTATION OF THE STOMACH*

By L. C. KINNEY, M.D.

SAN DIEGO, CALIFORNIA

CONGENITAL anomalies in the development or position of the stomach are exceedingly rare. It is relatively common to find anomalies in the ileocecal region, such as pericolic membrane or unusual position and attachment of the ileum, cecum or appendix. All stages of the normal embryonic rotation and descent of the cecum are found arrested and present in the adult tract. The appendix and cecum may remain fixed at the hepatic margin as a permanent position, or the tip of the appendix may be caught in the liver margin and be stretched out posteriorly the entire length of the ascending colon through the descent of the cecum. Failure of rotation is frequently seen in the presence of an ileum that enters the cecum posteriorly or externally instead of in its normal position.

On the other hand failure of descent or rotation of the stomach is exceptional. According to the classification of Nau, this condition must be termed an "incomplete embryonic diaphragmatic hernia." Paillard at the University of Paris, in 1903, reported only sixteen such cases in literature and only two on the right side. Griffin of Rochester, in his exhaustive study of 1912, reported only one case of embryonic hernia of the stomach on the right side. I have been unable to find another case in going over the literature since 1912.

The case presented herewith exhibits two types of non-rotation and failure of descent in the gastro-intestinal tract.

CASE 4103. Age sixteen months. Examined September 13, 1919. This patient was brought for examination suffering from violent dysphagia, accompanied by paroxysms of coughing and retching. The family history in the case was negative, the birth was normal, the child was breast fed, developed normally, and there were no children's diseases, no discomfort or dyspnea. During the latter part of the first summer there was some distress after nursing which was shortly relieved by carminatives. This patient was weaned one month prior to examination. Immediately following the artificial feeding she began to develop dysphagia which shortly amounted to violent paroxysms of pain. This was relieved by voluntary emesis, the child putting her finger down her throat to empty her stomach. She had been able to retain scarcely any food for the month preceding examination, had lost weight, showed evidence of malnutrition, suffered from the constant vomiting but exhibited no other symptoms. Temperature and respirations were normal, there was no cyanosis or dyspnea.

X-ray examination on September 13, 1919, disclosed a stomach lying above the liver on the right side in its proximal two thirds, the distal one third lying below the liver and these two portions communicating through what would be the normal position of the esophagus (Fig. 1). There is no filling defect in the stomach, the outline is smooth throughout, the pylorus lies in the midline tucked up against the liver. The distal one third of the stomach empties in two hours (Fig. 2), leaving approximately one fourth of the meal in the proximal portion at this time. At six hours (Fig. 3) the stomach is empty and the meal extends throughout the proximal colon. The cecum lies in the middle of the hepatic margin and the ascending colon follows the course of this margin in the usual non-rotated, non-descending position. No other portion of the tract is found in the hernia.

The treatment consisted in diminishing the size and the quality of the formula used, with frequent feedings and careful attention to the hysterical element present. The vomit-

*Read at the meeting of the Pacific Coast Roentgen Ray Society, Catalina Island, California, June 17-19, 1920.

ing disappeared when the proper formula was found, recurring for a few days in October, 1919. Renewed attention to the feeding and sedatives was followed by a complete disappearance of the symptoms. At twenty-five months this patient has the normal health and development for a child of her age.

FIG. 1. Case 4103. Stomach filled.

FIG. 2. Case 4103. At two-hour distal one third empty; proximal two thirds of stomach full.

The findings in this case check very closely with the position of the stomach in the embryo as seen from its first appearance up to the 11 mm. stage (Fig. 4). The stomach arises as a bulge from the esophagus at about 5 mm. of development and remains in this position, above the liver, until after the fetus attains 11 to 15 mm. At this time the stomach rotates to the left and a diverticulum appears from the posterior border to form the cardia. As described by Jackson in 1909, "In the 11 mm. embryo the cardia lies opposite the third or fourth dorsal segment," that is above the liver, "while in the 17 mm. embryo the two ends of the stomach have assumed their normal position," that is below the liver (Fig. 5). Interpreted in this light the stomach in this case occupies the position in a 9 mm. embryo with two thirds lying above the liver and the cardia having rotated to the right instead of to the left.

FIG. 3. Case 4103. Colon filled at twelve hours.

Following further the embryology of the cecum, the normal position of the cecum and appendix in the 95 mm. fetus is in contact with the liver. We have then, in this case, an arrested development in both ends of the tract, the failure of the cardia to rotate to the left and descend to its normal position underneath the liver on the one hand, and the failure of the cecum to rotate and descend from the liver margin to the right iliac fossa. This combines the position of the stomach as found in the 9 mm. embryo and that of the cecum present in the 95 mm. stage.

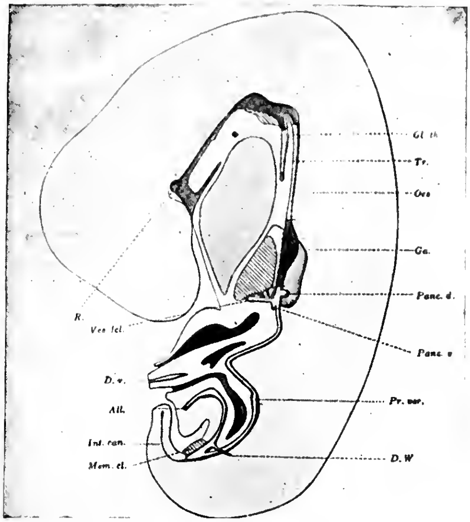


FIG. 4. 9 mm. embryo. Stomach above the liver.

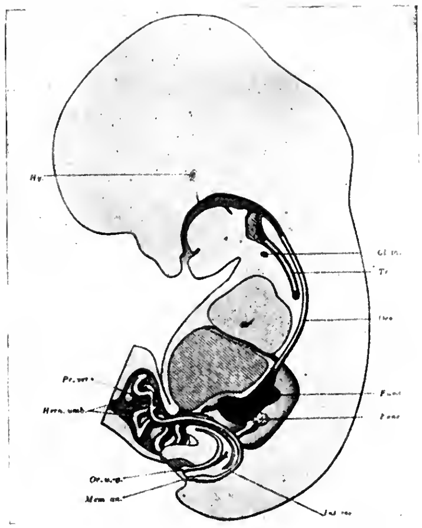


FIG. 5. 17 mm. embryo. Stomach below the liver.

The usual history of incomplete embryonic diphragmatic hernia is either death within the first few days or, passing this stage, the condition remains latent and is not discovered until some accident in adult life. The discovery in the present case was due to the gastro-intestinal upset incident to weaning, and has apparently no bearing upon the health or life expectancy of this child.

TRANSPOSED VISCERA *

BY W. O. UPSON, M.D.

BATTLE CREEK, MICHIGAN

IN view of the therapeutic and surgical significance of situs inversus it is surprising to note how little importance is attached to this abnormality by the medical world. Probably no other malformation will cause such marked deviation from the expected findings in diseases of the thoracic and abdominal viscera, and yet the condition has received but slight attention from great students and writers.

In literary study of the subject, one is astonished, and not a little humiliated, to note how small a number of cases have been reported which were detected by physical examination. Prior to 1902, by far the greatest number of cases were discovered on the operating table or at necropsy. Arneille[1] reported the case of a man aged fifty who had been examined five times for life insurance, and yet the complete transposition of his viscera had not been detected. Thierry[2] reported a case in which a thorough examination led to a diagnosis of appendicitis. The regular incision through McBurney's point was made, and the surgeon found that he was dealing with the descending colon. The operation was discontinued, and by a subsequent barium meal the fact was revealed that the cecum and appendix were in the left iliac fossa, and that the case was one of complete situs inversus.

The postmortem examination has led to the discovery of the great majority of cases of situs inversus. A somewhat exhaustive study of the literature on this subject shows that one of the earliest authentic cases was

*Read before the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., February 21, 1921.

recorded by Petrus Severinus of Rome in the year 1643.

In 1865, Gruber[3], after some laborious research, made a collection of seventy-nine cases of this curious anomaly, five or six of which were discovered during life. Forty-nine of his subjects were men, nineteen were women, and of eleven the sex was not mentioned. In seventy-one out of these seventy-nine cases both the heart and the abdominal organs were displaced, the remaining eight showed displacement of the abdominal organs only.

Küchenmeister[4], in 1893, increased the number of known cases to 149. In 1895, Price[5] had made further researches, bringing the total up to 190, and this comprised all the cases recorded in medical literature up to that year.

Arneille[1], in 1902, made an elaborate study, with the collaboration of a number of internists and anatomists, and reported forty additional cases.

The development of the *x*-ray as a means of diagnosis has facilitated the discovery of this condition in the living subject, and the number of citable cases has multiplied. The first case discovered by the *x*-ray was one of dextro-cardia, reported by Vehsemeyer[6] in 1897. Since that time more than thirty cases have been recorded in which the *x*-ray has been used either to originate or to confirm the diagnosis.

Kerr, in ten thousand autopsies, covering a period of ten years, found only two cases of this anomaly. Bland Sutton reported the discovery of only one case in the course of three thousand abdominal sections.

Because of its importance in the diagnosis of abdominal diseases, it seems appropriate to mention in this connection the condition in which the colon fails to rotate. In this situation the small intestine occupies the right side of the abdomen, and the colon is confined almost entirely to the left of the midline. The cecum is found in the left iliac fossa. Reid[7], in 1836, reported a case of colic and other abdominal pains, terminating fatally, in which the cause of death was given as "ileus". There was no operation. At the autopsy the colon was found to lie entirely on the left side, with the cecum in the left iliac fossa. The small intestines were pushed well to the right. The author does not mention the position of the other abdominal organs. This is apparently the first case of non-rotation of the colon to be reported. In 1916, Dr. J. T. Case[8] reported a case in which there were occasional acute pains in the left iliac fossa. After an *x*-ray study with the aid of an opaque enema, the diagnosis was made of left-side appendicitis, with the colon occupying the left-side position. The operation confirmed the diagnosis.

There are cases of incomplete or partial transposition of the viscera, but, according to Lochte[9], these are far less common than the condition of the complete inversion. Up to 1898 he was able to collect but thirteen cases of this variety. Dextro-cardia may be found with the abdominal viscera in the normal position, or the abdominal organs may be transposed while the thorax is perfectly normal.

Osler[10] claims that in cases of partial inversion of the viscera, and especially that of the thoracic organs, death is likely to occur in infancy.

In an attempt to ascertain the frequency with which this condition is met, I have taken the liberty of corresponding with a number of roentgenologists throughout North America, and a summary of their replies follows:

Dr. Kenneth Dunham. Only two cases, both of these complete transpositions. None within the last five years.

Dr. A. W. Crane. Thinks about three cases to the thousand observations.

Dr. J. G. Van Zwaluwenburg. Two cases of complete inversion, seven or eight of incomplete rotation of the colon, in approximately six to eight thousand observations.

Dr. Wm. H. Stewart. Three cases of complete inversion, two cases of incomplete rotation of the colon.

Dr. Russell D. Carman replies by sending a reprint by Dr. Willius[11] on two cases of

complete inversion, and one of dextro-cardia.

Dr. Lewis Gregory Cole. No cases of situs inversus observed, four or five cases of incomplete rotation of the colon.

Dr. Alfred L. Gray. One case of complete inversion, two of incomplete rotation of the colon, one of dextro-cardia, in which no examination was made of the abdominal organs.

Dr. Arial W. George. Six cases of dextro-cardia, in which no examination was made of abdominal organs. Two cases of complete inversion, three cases of incomplete rotation of the colon, out of 10,551 examinations.

Dr. Edward S. Blaine. Eight or nine cases, all of complete inversion. One of incompletely rotated colon.

Dr. Clarence F. Ball. Cites a remarkable instance of four cases of inversus in one family, including the grandmother on the father's side. Dr. Ball, in conjunction with Dr. E. J. Rogers, is preparing a report of the case.

Dr. G. W. Holmes. Reports that he has not kept definite data, but that he has had five or six cases. "Most of these have been complete, and where there was transposition of the heart the diagnosis had been made previous to the *x*-ray examination."

Dr. Henry K. Pancoast. Reports three cases, in which the heart as well as the abdominal organs were transposed. Also three cases of incomplete rotation of the colon. "In these three cases condition was not known until after *x*-ray examination was rendered."

Dr. G. E. Pfahler. "I think I have seen about half a dozen cases of complete situs viscerum inversus. In all the cases which I have observed the inversion was complete."

Dr. L. T. LeWald. "Altogether I have studied twenty-two cases of complete situs inversus. I have seen one case in which there was a complete situs inversus with an incomplete non-rotation of the colon. I know of one other case of autopsy in a child in which there appeared to be complete transposition and complete non-rotation of the colon. I have seen three cases of complete non-rotation without transposition."

At the Battle Creek Sanitarium there have been observed six cases of complete inversion, two of dextro-cardia, and five of incomplete rotation of the colon, out of fifteen thousand barium meals.

Various theories have been advanced regarding the causes of situs inversus, but these theories are of major importance only to the embryologist and the anatomist and are too technical to be discussed at length in a paper of this kind. A cursory review of some of these theories may, however, be acceptable.

Adami[12] believes that the most likely explanation is that the main current of the blood to and from the germinal area becomes diverted at an early stage of existence, and thus purely mechanical influences cause the vessels on one side of the organism to receive more blood and therefore to grow more vigorously than those of the other side. Karashima[13] propounds the theory that trauma in late embryonic life might cause the malformation.

Another theory is expressed by the term "Cryptoplasmic Variation," in which it is suggested that in the germ-cell there is predilection after the ultimate form of the body, which may induce this abnormality.

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DISCUSSION

DR. E. S. BLAINE. I have observed several cases of situs inversus but every one of these was a complete reversal of the position of both the thoracic and abdominal organs. From my experience I concluded that the statement by German observers that this condition is always a complete transposition was correct. They report no authentic instances of reversal of thoracic viscera with normal position of abdominal organs or vice-versa.

Whenever I find a reversed heart, I give the patient a few swallows of opaque material and invariably find that this enters a right-sided stomach, and from this conclude that all the abdominal organs are in situs inversus. It is very interesting to find that Dr. Upson's work has served to establish that a partial reversal of viscera does occur.

MR. H. W. DACHTLER. Were these hearts normal clinically, or was there evidence of congenital defects?

DR. L. T. LEWALD. As Dr. Upson said, I have seen 22 cases. In the male the right testicle hangs lower than the left. One case was examined by the Army Examining Board. I was in Columbus, Ohio, and had the diagnosis confirmed by an x-ray examination made by Dr. C. F. Bowen.

The first case I saw was at Bellevue Hospital, and the transposition was complete. We knew that the transposition involved even the suprarenals and the kidneys, for I performed a postmortem examination.

I have been asked if these people are left-handed. I want to ask Dr. Upson if in gathering his statistics, he has any information on this point.

I have seen a few cases of right-sided heart alone, but usually the transposition is complete.

DR. W. O. UPSON. Regarding the relationship between left-handed people and situs inversus, I have not found anything in the literature, or noted anything in connection with our own cases to suggest that they are in any way related to each other.

The point that I wish to lay emphasis on is the importance of transposition of the viscera, and partial transposition of the viscera in the diagnosis of thoracic and abdominal diseases. I know of nothing that will confuse so much as these conditions, and it is a fact that the physical examination very frequently fails to detect the exact situation, especially in the transposition of the abdominal viscera.

In reply to Mr. Dachtler's question, in our cases the hearts were clinically normal.

REPORT OF A CASE OF DIVERTICULUM OF THE LOWER PORTION OF THE ESOPHAGUS

By H. W. DACHTLER

TOLEDO, OHIO

THE patient, a female aged thirty-six years, unmarried, was referred by Dr. W. H. Fisher in January, 1920, for an *x*-ray examination of the intestinal tract to determine, if possible, the cause of some obscure abdominal symptoms.

The family history was negative, her father was living and well at eighty-two and the mother living and well at seventy-six. A number of brothers and sisters were all well.

The patient was well as a girl. When eighteen years old she had a mild typhoid infection without complications, and made a good recovery.

Her present trouble began in 1908, with pain in the appendix region and some gastric disturbances, and for six weeks she vomited every time she attempted to take food. During this period she received nutritive enemas. She did not respond to treatment and as the consulting physician thought this a neurosis she was taken to another city for observation and was there operated upon and both ovaries and the appendix removed. These were said by the patient to be diseased but no authentic history of the findings was obtainable. She did not vomit after operation but had much distress in her stomach. She evidently was not completely relieved, for she received osteopathic treatments, and after each treatment "raised much mucous." She gradually got better but has had stomach trouble ever since and has vomited occasionally. In 1916 a cervical adenitis was operated and three months later her tonsils were re-

FIG. 1. Oblique. Pouch slightly posterior and above diaphragm.

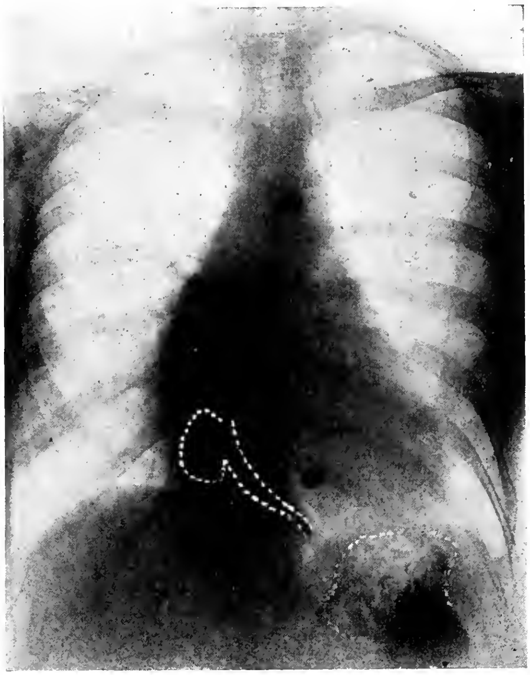

FIG. 2. Anteroposterior. Pouch to right of esophagus.

moved and said to be badly diseased. During 1919 she was worse and lost weight, and she was seen by me in January, 1920.

On examination she was found to have a marked scoliosis, but examination of the lungs was negative and there was no evidence of vertebral disease. The first of the barium meal was seen to enter a pouch to the right of and partially posterior to the esophagus, about four inches from the cardia, and then to overflow into the lower portion of the esophagus and, after some delay at the cardia, to enter the stomach. Throughout the taking of the barium mixture there was some delay at the cardia, but this was not sufficient to cause any dilatation of the esophagus. The stomach was atonic and three inches below the umbilicus, but was otherwise normal and evacuation was complete in five hours. There was very definite delay in the duodenal-jejunal region suggesting adhesions and adhesions around the terminal ileum which also caused some delay in the lower ileum. Later, when the colon filled, marked adhesions were found involving the transverse colon.

April 29, 1920, she was again operated and the adhesions were broken up.

I saw her again in March, 1921, for a sinus examination, and she had gained in weight, looked better and claimed to be much stronger and to have a good appetite and very little stomach trouble. While she claims to have at times some difficulty in swallowing it is hard to elicit any symptoms that can be attributed to the diverticulum. They are more suggestive of a cardiospasm. Patient has refused to submit to examination with an esophagoscope.

This case was reported owing to the apparent rarity of a diverticulum in this region. It does not appear to be a traction diverticulum and its etiology is, to me, uncertain.

TOTAL RADIATION FALLING ON SURFACES EXPOSED TO POINT SOURCES

By JULIUS KAUFMAN, M.D.

BROOKLYN, NEW YORK

IN our study of *x*-ray physics we noted that there was little if any distinction made between the "intensity" of radiation falling on a unit area,[1] and total radiation falling on a finite area. Very often the same laws, though not applicable, were applied to both. The inverse square law, for example, was often used to compare radiations on similar surfaces exposed to the same source at different distances. Thus it was not uncommon to find it stated without reservation that a surface exposed at twice the distance of a similar surface would receive one fourth the radiation of the nearer surface provided both were exposed to the same source. This is not true. We will show that the farther surface will receive radiation greater than one fourth. As a matter of fact if two like surfaces are exposed to the same source at different distances, the farther surface will always receive greater radiation than calculations based on the inverse square law would lead us to believe. If we wish to compare radiation on surfaces with scientific accuracy, it may only be done by determining the total radiation falling on each surface individually. I have never seen a method of doing this.

I have written what follows chiefly for three reasons:

1. I wished to show a method by which we could determine the total radiation falling on a surface exposed to a point source.

2. I wished to show that the inverse square

[1] By "unit area" is meant an infinitely small area approaching the point as a limit.

law could not be used to compare radiation on surfaces, its use being limited solely to the comparison of intensities.

3. If we admit that the radiation on like surfaces exposed to the same source varies inversely as the squares of the distances, then it must follow that the intensity of similar points on both surfaces bears the same relation. The admission of such a fact is misleading and may lead us into gross errors. We will illustrate just what we mean by a hypothetical case. Suppose we exposed a flat circular surface with a ten-inch diameter, at an eight-inch distance from the source, by overlapping two equal exposures, the targets being ten inches apart, perpendicularly above diametrically opposite points on the circumference of the surface. Suppose we moved our surface to 16 inches (twice the original distance), exposed as before, increasing our exposure time by four. If we were then to compare the intensity of similar points on both surfaces, we would find that they were not equal at all, but that all points on the farther surface received a greater intensity of radiation. The central point on the farther surface, for example, would receive an intensity of radiation greater by 42 per cent than the corresponding point on the nearer surface. When two similar surfaces are exposed to the same source at different distances, the intensities of similar points bear no direct relation to the distances of exposure.

I. THE FALLACY OF APPLICATION OF THE INVERSE SQUARE LAW IN RADIOGRAPHY

Those who apply the inverse square law do it with the following as the basis: They say that the radiation falling on a flat surface at a given distance from a source would fall on four times as large an area at twice that distance. From this they infer that the original surface would receive one fourth the original radiation at twice the distance. This would be so if the radiation over our surfaces were equally distributed. But this is not the case. The intensity on any surface increases as we go toward the perpendicular ray and decreases as we go away from it. Our original surface would get proportionately more radiation if near this ray, and correspondingly less if removed from it.

Flat surfaces, exposed so that the perpendicular ray is central, always receive greater radiation than calculations based on the inverse square law would lead us to believe. If, for example, two 8″ x 8″ surfaces were exposed to the same source for the same period of time, one at 10 inches and the other at 100 inches, the second surface would not receive one one-hundredth (1/100) of the radiation of the first, but actually one seventieth (1/70). That is, it would receive 40 per cent more than calculations based on the inverse square law would lead us to believe.

II. TOTAL RADIATION ON ANY SURFACE: THE VERSIN LAW

Given any surface ABD (Fig. 1), receiving a cone of rays from a source S.

To find how much of the total radiation of the source will fall on surface ABD if the total radiation of our source is Q.

With S as a center and R as a radius, circumscribe the sphere, EFG. The cone of rays going to our surface intersects the surface of our sphere in the circle HCL. The plane of circle HCL cuts off a portion of the surface of our sphere HML. Such a surface so cut off is known as a zone of one base. Its area is equal to $(2\pi R) \times (CM)$.

(The area of a zone is equivalent to the circumference of a great circle by the altitude of the zone.)

If R.S., R.Z., and R.X. represent the radiation on the sphere, the zone and the surface respectively, then

$$\frac{R.Z.}{R.S.} = \frac{(2\pi R) \times (CM)}{4\pi R^2}$$, in which

$(2\pi R) \times (CM)$ is the area of the zone, and $4\pi R^2$ is the area of the sphere.

$$\frac{R.Z.}{Q} = \frac{CM}{2R}$$

$$R.Z. = \frac{Q}{2} \times \frac{CM}{R}.$$

But $\frac{CM}{R}$ is equal to $\frac{(R - SC)}{R}$, which in turn is equal to $1 - \frac{SC}{R}$, which in its turn is equal to $(1 - \text{Cos. } \alpha)$, so that

$$\text{R.Z.} = \frac{Q}{2} \times (1 - \text{Cos. } \alpha).$$

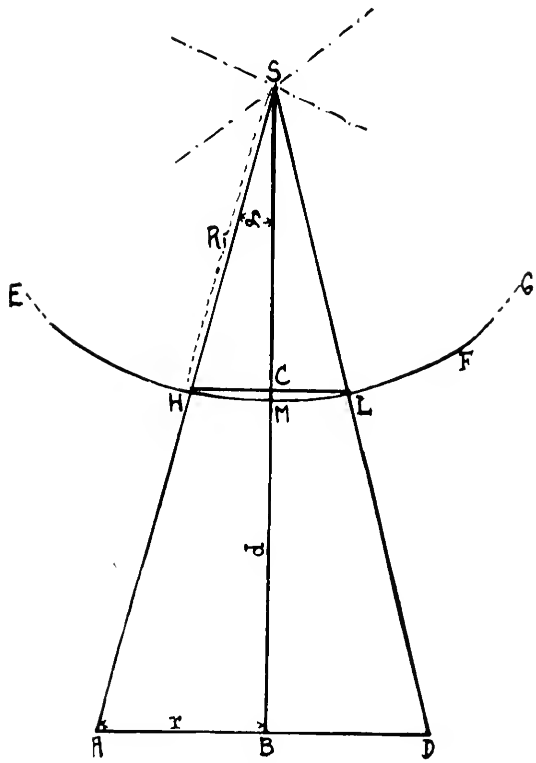

Fig. 1.

But R.Z. is equal to R.X., and $(1 - \text{Cos. } \alpha)$ is equal to Versin α, or

$$\text{R.X.} = \frac{Q}{2} \times \text{Versin } \alpha.$$

From the above expressions, we may express the following law:

The total radiation on any surface receiving a cone of rays from a point source is equal to half the total radiation at the source by the Versin of the cone angle.[2]

If the surface exposed be a flat surface, then the expression

$$\text{R.X.} = \frac{Q}{2} \times \text{Versin } \alpha, \text{ becomes}$$

$$\text{R.X.} = \frac{Q}{2} \times \left(1 - \frac{d}{(d^2+r^2)^{\frac{1}{2}}}\right)$$

in which d is equal to the distance of the surface from the source, and r is its radius.

If we were to expose a flat surface whose radius was 8 inches to a point source at a distance of 10 inches, we would find from the above expression that our surface received 0.11 per cent of our total radiation. If now we removed this surface to a distance of 100 inches it would receive .0016 per cent of the total radiation, and not .0011 per cent which it should receive according to calculations based on the use of the inverse square law. If we had increased our exposure a hundred times when we removed our surface to 100 inches, the total radiation over it would be greater than the total radiation on the nearer surface. If we were to analyze the intensities of points on each surface, comparing corresponding points, we would find that each point on the farther surface, with the exception of the central point, received a greater intensity of radiation. A comparison of the intensities of the central points would show them to be equal. If instead, we had irradiated our original surface by means of overlapping two or more exposures, and had then irradiated a similar surface at ten times the original distance, increasing our exposure by a hundred, a comparison of the intensities of corresponding points would show that the intensity of all points on the farther surface was greater than similar points on the nearer. The above means that if we expose a given area at a given distance by a certain technique, correcting our original exposure time by use of the inverse square law, upon removing this area to another distance, does not insure the same irradiation as originally received. The disparity is at times alarming, especially when the areas have been irradiated by overlapping exposures, when they are large, and when the distance removed is great.

[2]A cone angle is that plane angle which would generate the cone if revolved about one of its sides as an axis.

[3]This expression may be obtained by substituting for the Versin its equivalent in terms of d and r.

X-RAY SPECTRA AND THE STRUCTURE OF MATTER*

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IS ALL matter made of some common elemental unit? If so what is this unit, and by what differences of arrangement are apparently different kinds of matter constructed? These are fundamental questions demanding answers at the hands of the physical sciences.

In the past decade an abundance of data has accumulated upon which very plausible theories have been constructed which attempt to answer these questions. The two most prolific sources of information have been radioactive materials and the electric discharge (or *x*-ray) tube. When the roentgenologist makes an *x*-ray shadow-photograph of a hand, he is generally satisfied with the knowledge of the form, texture and arrangements of the grosser structures of the hand which the radiogram yields. The physicist substitutes for the hand an inorganic crystal and is not satisfied when the *x*-ray negative has disclosed the complete arrangement of the atoms within the crystal, but demands that it also tell the structure of the atom itself.

The rays emanating from the target of an *x*-ray tube are a collection of electro-magnetic waves of various wave-lengths similar to heat radiation, light and wireless waves. They differ only in the length or frequency of their waves. Thus, wireless waves are measured in meters, light waves in thousandths of a millimeter and *x*-rays in ten millionths of a millimeter. Some appreciation of the shortness of this wave length may be gleaned from the statement that if an *x*-ray wave were to be stretched to the length of an inch, the inch by a like stretching would equal the length of the earth's radius.

The fundamental idea whose application has made it possible to separate this mixed bundle of rays into its component wave-lengths is due to Dr. Laue of Zurich, and its application has been ably extended by W.H. and W. L. Bragg and others. It assumes that the atoms in a crystal of pure chemical are regularly arranged in planes with uniform spacing. It should then be possible to use such a crystal in the place of and with the same effect for *x*-rays as the physicist uses the familiar "diffraction grating" for visible light.

Referring to Figures 1 and 2, it will be seen that if the crystal planes are regularly arranged, a reflected beam will arise when the waves from adjacent planes are in the same phase. The path difference of the waves must then equal one or more whole wave-lengths.

Mathematically this is written

$$n\lambda = 2a \sin \theta$$

Where n = a whole number, 1, 2, etc.
θ = the angle of incidence
a = the distance between crystal planes
and λ = the wave-length.

If now the crystal be rotated and the reflected beams be allowed to fall upon a photographic plate, each part of the plate will receive rays of a different wave-length according to the angle θ; and the intensity of any particular wave-length may be found from the relative density of the plate. This photographic representation of the resolved wave-lengths may be called an "*x*-ray spectrum".

a. Line Series Due to Crystalline Structure

If in the crystal there is any regular arrangement of atoms, it should be possible to have several sets of parallel planes. The distance between planes in any one set is the

*Read before the Second Annual Meeting of the Central Section of The American Roentgen Ray Society, St. Louis, Mo., February 21, 1921.

same, but it is different from that between members of any other set. Now if a crystal is mounted with careful reference to the position of its atomic planes and is subjected to a beam of x-rays with only one wave-length, when the crystal is rotated a reflected ray beam of a single wave-length, all the possible plane sets are exposed and all the possible lines appear simultaneously on the plate. These lines are due to and characteristic of the atomic arrangement in the crystalline structure of the powder used.

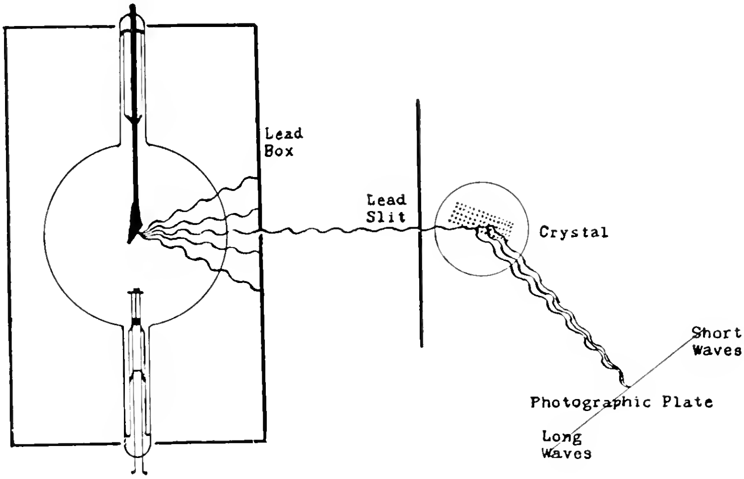

FIG. 1. Diagram of the x-ray spectrometer.

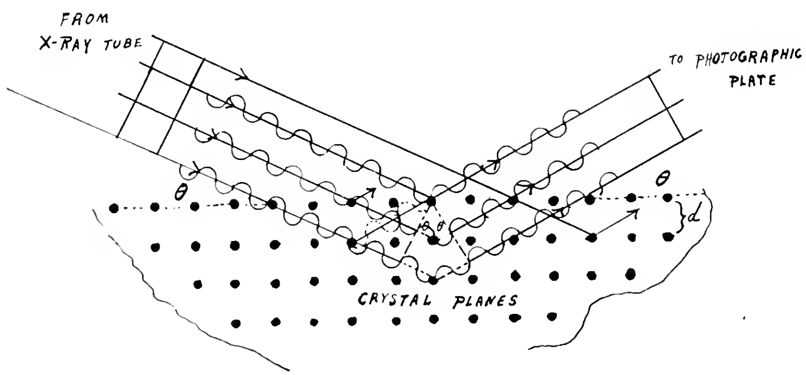

FIG. 2. Diagram illustrating the principles of x-ray reflection for multiple atomic planes.

beam will occur whenever the values of θ and a are such as to satisfy the above equation or whenever $\sin \theta = n\lambda/2a$. Since $\sin \theta$ cannot have a value greater than 1, only those sets of planes with an a-value greater than $\lambda/2$ will be represented by a reflected beam affecting the plate.

Drs. Hull and Debye independently suggested that complete chaos of arrangement would do as well as exact uniformity. Dr. Hull, accordingly, pulverizes the crystal, places it in a small tube and backs it with a photographic plate. When exposed to an x-ray beam of a single wave-length, all the possible plane sets are exposed and all the possible lines appear simultaneously on the plate.

One may now measure the angle θ by the position of the line on the plate, and the wave-length of the x-ray beam being known, one can easily calculate the distance between the parallel planes in each set. Then, knowing the number and the relations of the plane sets, one can reconstruct the geometrical pattern of the crystal and determine the position of the atoms themselves.

In this way, Dr. Hull and others have examined the crystalline structure of innumerable substances and have demonstrated that such physical properties as tensile strength,

hardness, etc., bear a definite relation to the arrangement of the atoms, and that, knowing the arrangement of the atoms, these physical properties can be inferred.

Once the characteristic lines of a crystal have been charted, it may readily be identified again, and since no two chemicals present identical crystalline structure, this chart is characteristic of its chemical composition.

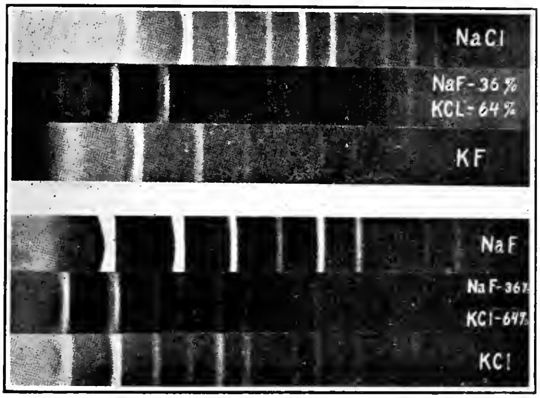

FIG. 3. Spectra of mixed crystals of NaF and KCl. (By courtesy of Dr. Hull.)

Dr. Hull has pointed out the value of this method in the analysis of mixtures of chemicals in crystalline form. This is exemplified in the photograph in Figure 3 representing the spectrum analysis of a mixture of NaF and KCl. Ordinary chemical methods demonstrate only the presence of the four elements and their proportions, but cannot tell in what combinations they exist. It is readily seen that by a comparison with the x-ray charts of the pure chemicals no mistake in the combination of the four elements could be made. Quantitative measurements are also possible by the use of comparison samples.

b. Characteristic Lines Due to Atomic Structure

Figure 4 shows the distribution of energy throughout the spectrum of a beam of x-ray produced by a tungsten target under various voltages. It will be observed that there is a definite lower limit in the wave-length (on the "blue end" of the spectrum) determined by the maximum voltage. Above this lower limit (towards the "red end") every wave-length is present with some amount of energy, but this energy is not evenly distributed, and it will be noticed that some regions have more energy (represented by an elevation of the line) than those on either side. These peaks or elevations are found to be characteristic of the metal in the target, and if the regions of extraordinary energy be represented by a central line passing through the peak, the "characteristic spectrum" of the emitting metal is obtained. M. Sommerfeld has mapped the characteristic spectra of practically all the metals.

If the corresponding lines of these characteristic spectra are designated by the conventional letters used by Sommerfeld as in Figure 5, certain remarkable relations are found to exist between them.

1. The same lines appear in practically the same order in the spectrum of every metal.

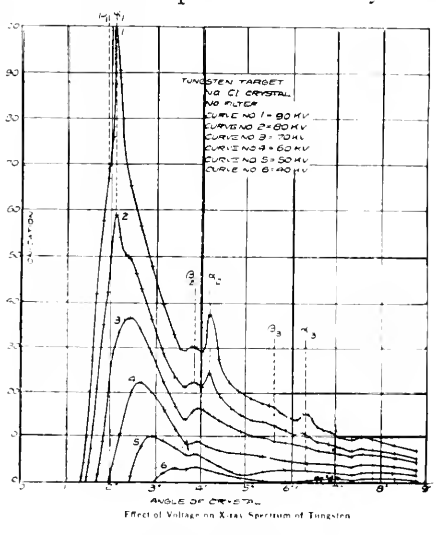

FIG. 4. X-ray spectrum and light intensity measured vertically, wave length horizontally. (By courtesy of Dr. Hull.)

2. The wave-length of any particular line grows shorter as the atomic number (and the atomic weight)of the element increases.

3. If the number of waves per centimeter ($1/\lambda$) be used instead of the wave-length, then the difference between various pairs of lines in the same spectrum is the same; as—

$$L_\delta - L_\gamma = L_\beta - L_{\acute{\alpha}} = L_\theta - L_\rho = \text{etc.}$$

This ability on the part of the radiating atom to emit its energy in certain definitely related frequencies gives a clue to the structure of the atom itself. On the basis of facts such as these, Bohr, Kossel, and Sommerfeld have developed a hypothetical atom which should theoretically emit and absorb energy exactly as actual atoms do. Figure 6 is the representation of such an atom.

It consists of a positive nucleus, outside of which there are as many electrons as the "atomic number" of the element. The electrons are supposed to be in motion and are confined to shells which may be spherical or ellipsoidal in shape. Mathematical considerations require that the energy of the system be determined by the position of the electrons with respect to the nucleus, being greater for the electrons in the more distant positions, so that the removal of an electron from the outer to an inner ring or shell represents a loss of energy. When x-rays are emitted by an atom the energy of the atom must be reduced, and this must mean that one or more electrons have fallen into an orbit closer to the central positive atomic nucleus. This falling in may be produced by the application of an external force, i.e., by means of the cathode stream or x-rays. If an electron falls to the inner ring from the next outer ring less energy will be given up than if it fall from the outermost ring. Since, according to the theory of Planck, the energy given up is equal to a constant (h, "Planck's Constant") times the frequency of the emitted wave, a higher frequency and a shorter wave-length will result with the longer fall in the latter case. In each shell there may further be as many ellipses as the serial number of the shell counting outwards from the nucleus.

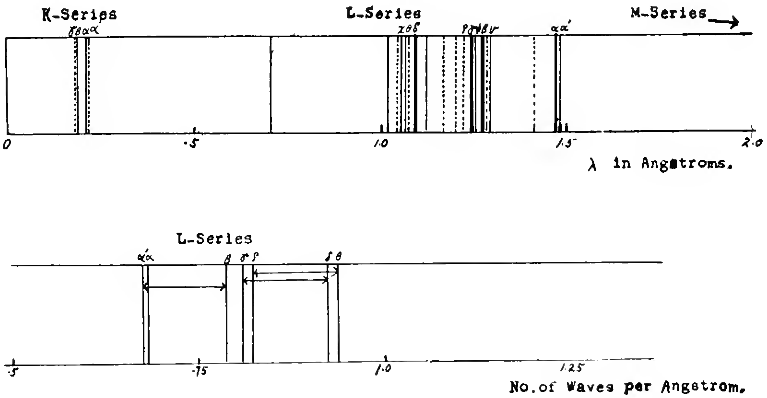

FIG. 5. Diagram of lines in the tungsten spectrum.

In the "characteristic" spectrum at least three series have been identified corresponding to three shells; the K, L, and M series, in the order of the increasing wave-length or softness of the ray. When an electron falls from any of the outer rings to the K or inner ring, the K series of lines is emitted, when falling to the L′ or L″ rings, the L series is emitted, etc.

Referring to Figure 6 it appears that this structure of the atom readily explains the regular frequency differences just described. For when one compares the amount of energy given up by an electron falling from the inner M ring to the outer L ring with that of one falling from the same ring to the inner L ring, less energy will be emitted in the former case. The first case gives the L_ϵ spectral line. The latter gives the L_η line. The frequency difference in the two lines is thus dependent upon the difference in the L rings. Moreover, this same frequency difference will appear in the spectral lines for every ring outside the L rings from which electrons could fall and give rise to a pair of equidistant "L" lines.

Further it is clear that if the electron must be driven closer to the nucleus to produce

"K" lines than "L" lines, the agent producing such dislocation must possess more energy. In the x-ray tube the driving force is determined by the potential applied to the tube and a higher potential must be used to produce "L" lines than "M" lines and still higher to produce "K" lines, and only when it reaches a certain critical value will the "L" lines and the "K" lines appear and when one of a series is produced all of that series should appear simultaneously. This has been experimentally verified.

Further, for the atom of large atomic number (atomic weight) there are a larger number of protecting electrons in the outer shells, since they are presumed to equal the atomic number of the element; and therefore a higher voltage should be necessary to penetrate to an inner ring of the heavier atoms to produce any particular series. This also has been demonstrated.

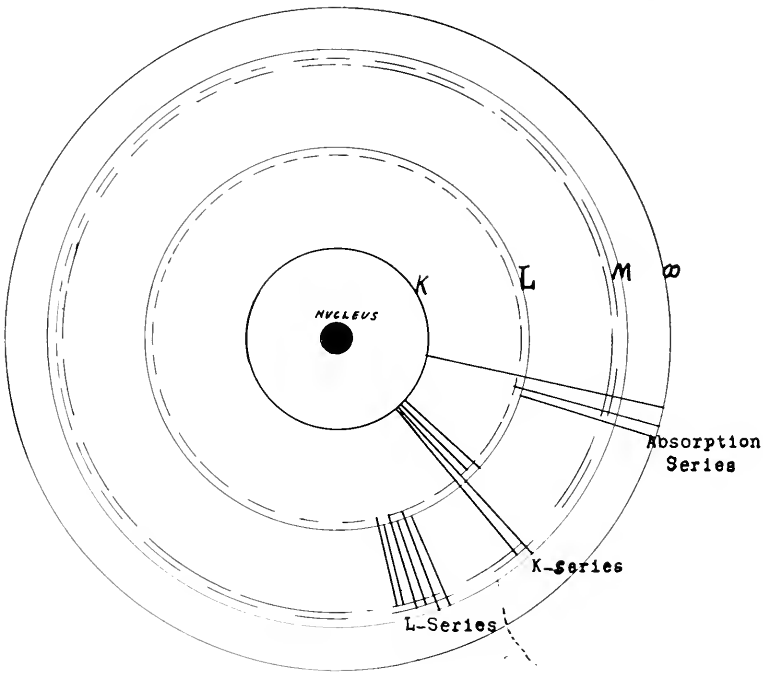

FIG. 6. Diagram of Bohr's hypothetical atom.

c. Absorption Bands Due to Atomic Structure

The phenemenon of absorption is in a sense the reverse of the process of emission and represents the absorption of energy of the atom. This means that electrons are displaced towards an outer from an inner ring. In fact there is evidence that in the atom the outer rings are normally full and if once an electron is dislodged it leaves the range of the nuclear influence entirely. To dislodge an electron from any of the rings would require slightly more energy than that represented by the highest frequency line of that series. If we pass a beam of x-rays consisting of all wave-lengths through a thin sheet of any element, we should expect those wave-lengths slightly shorter than the shortest wave-length of each series in the emission spectrum of that element to be absorbed, leaving dark bands. Bands have been observed for the "K," "L′," and "L″" series of some metals.

Langmuir has pointed out that certain groupings of electrons give more stable conditions than others; for example, two in the inner ring and eight in the second ring represent such a stable condition. This represents the conditions in the element Neon, a singularly inert "noble gas". Just beneath it in order of atomic number is Fluorine

(whose atomic number is 9), with two electrons in the inner and seven in the outer ring; just above it stands Sodium (whose atomic number is 11), with one electron in excess of the stable condition. Neither of these is stable, but if they should come into intimate contact so that the sodium atom could give up one of its electrons to the fluorine (or possibly share it), then each of the two atoms would have the required number for stability. The loss of an electron would leave the sodium atom a positively charged ion, while the gain of an electron would make the fluorine atom a negatively charged ion. Several such ions together due to attractive forces would arrange themselves so that the oppositely charged ions were at the adjacent vertices of a cubical structure. This has been found to be the case by the x-ray analysis of the crystals of this substance. Further, when NaF is melted it is found to be an electrolytic conductor, as would be expected if it were a collection of ions.

This theory of atomic structure has still several things to explain. If the electrons rotate about the nucleus they should give rise to magnetic polarity and a collection of atoms should show paramagnetic properties. As a matter of fact, liquid hydrogen has been shown not to be paramagnetic. These objections may be overcome by assuming a vibratory motion or a rotation of the electron about some fixed position of rest.

The idea that the different elements might all be constructed by the combination of individual particles of some mother substance such as hydrogen is not a new one. Hydrogen was first suggested by a British physician, Dr. Prout, as early as 1815. Now after a lapse of a century, scientists are supporting the original theory with very convincing experimental proof. Our conception of the hydrogen atom now is that of a certain nuclear content called the hydrogen nucleus, and one outer electron.

One of the most serious objections to Prout's theory, which has only lately been successfully met, is that if hydrogen is taken as the standard with an atomic weight of 1, the remaining atoms built up of these units should always have the atomic weights in whole numbers and fractional atomic weights would be impossible. As an example to the contrary one may quote chlorine with an atomic weight of 35.46. In recent experiments by Dempster and Aston, it has been shown, however, that such elements with fractional atomic weights are not homogeneous elements but are mixtures of atoms with unlike atomic weights but with apparently identical physical and chemical properties except in respect to their atomic weight. Such elements are called "isotopes." Chlorine is shown to be a mixture of atoms having the atomic weights of 34, 35, 36, and 37. Similar conclusions are drawn in regard to several of the other "elements."

Another objection to the idea of hydrogen being the true mother substance rests on the failure to demonstrate the production of hydrogen on the disintegration of the more complex atoms. Most materials seem to produce or evolve simple multiples of hydrogen, e.g., helium from radium. But in some recent researches, Sir Ernest Rutherford bombarded nitrogen with the α-rays of radium and found quite conclusive evidence of the formation of hydrogen.

I have attempted to tell you in part what the study of the x-ray and its use in connection with other problems has played in the progress that has been made by the physicist toward the solution of the problem of the ultimate constitution of matter. But should this theory, or some other that may have to be substituted for it as an explanation of the atomic structure, be accepted as a fact, the scientist is still left with the problem of the constitution of the nucleus and of the electron.

[We wish to acknowledge our appreciation of the kindness of Dr. A. W. Hull, of the Research Laboratories of the General Electric Company, for permission to publish Figures 3 and 4.]

RADIOGRAPHY OF THE MASTOID*

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IT HAS been said that the radiograph is the otologist's best consultant. If it is to be used as so important a consultant it must be considered after obtaining the complete clinical data.

To be of its greatest value it must be the most perfect plate that can be made. Any motion, however slight, will produce a blur and obscure the fine detail of the mastoid cells and will perhaps lead to an erroneus interpretation. One of the prime requisites in taking mastoid plates is that they be taken with the finest focus tube. A plate taken with a broad focus tube at the usual distance is quite as objectionable as motion because of the resulting loss of detail.

The position which gives the most desirable view of the mastoid cells is that first described by Law and later adopted by the U.S. Army. This is in brief: patient lying on the side with the head on a horizontal head holder, the pinna folded forward and the mastoid in contact with the plate, the eyes in a vertical plane, and the tube so placed that the central rays will enter at a point about an inch and a half above and the same distance behind the external auditory meatus of the side uppermost. This superimposes the internal and external auditory meati of the side in contact with the plate, and shows its anatomy with the least distortion and superimposition of the parts. It is for this reason that the anteroposterior position is not advisable.

The resulting radiogram should show the temporal bone in its entirety, but as little of the surrounding area as possible. This can be obtained by using a small cone brought in close relation with the patient's head, thereby eliminating the fogging effect of scattered irradiation seen in plates including more of the skull.

The question of preference between films or plates is usually one of individual taste, although the same wealth of detail and contrast that can be obtained on a plate does not seem to be obtainable on a film.

Radiographs made with intensifying screens, either single or double, no matter how used, are not desirable for mastoid radiography because of lack of detail and contrast, and on account of graininess. Stereoscopic views of the mastoid have the same advantage over flat plates that holds true of stereoscopic plates of other parts of the body. They are, however, a refinement of technique and not a necessity. In the majority of cases the flat plate will yield the same amount of information if carefully studied.

The radiographs of this region require a longer exposure (because of the extreme density of the structures) than those of any other part of the body, and consequently may show motion.

Not infrequently the patient's condition offers difficulties in getting a satisfactory plate. There may be so much post-aural pain that the patient is unable to rest his head securely enough to prevent trembling during exposure, even when held in head-holder. This may be greatly intensified by folding the pinna forward.

Knowledge of the variations occurring in the anatomy of the part is necessary for correct interpretation of the radiographic findings.

The anatomical distribution of the cells cannot be determined from the shape or size of the mastoid process or the external contour of the patient's head. Both the anatomical distribution and cell structure, however, may be shown by roentgen ray examination.

Mastoids are usually divided into three

*Thesis presented on application for membership in The American Roentgen Ray Society.

types according to cellular structure found, namely pneumatic, diploic, and mixed.

The pneumatic cells are to be found in the mastoid and squamous processes and not in the petrous portion. Occasionally we find mastoids in which there appear to be several pneumatic cells coalesced into one large cell area. Law[1] states: "The structure of the mastoids of both sides are, as a rule, similar. Where there is a large cell on one side there will be a correspondingly large cell on the other. This occurs so frequently that we can consider the two mastoids alike in structure."

Diploic cells are always found in the base of the petrous portion about the antrum, although they may extend into the mastoid process, in which they are limited to the region anterior to, or perhaps overlying the lateral sinus. More rarely they extend into the squamous portion.

In about 80 per cent of cases the mixed type are present. In these cases the pneumatic cells always occupy the periphery.

Mouret[2], in his classification, speaks of the "sclerotic" as a type, although he suggests modifying this by the term "compact." A dense mastoid without any evidence of cellular structure is not an anatomical entity,but the result of pathology, and can be readily recognized by the roentgen examination. A clinical history of previous ear infection can always be obtained in these cases.

Cheatle[3] in the examination of over five hundred specimens of the temporal bone found ninety-six, or not quite 20 per cent of the bones to be made up of the fine diploic type of cells to which he gave the name "infantile" because of the extreme thickness of the outer wall and the under-development of cell structure, the so-called "fetal" type which persists throughout adult life.

Bigelow[4] and Gerber[5] have discussed this type comprehensively from a radiographic standpoint.

The otologist has learned from experience that when a small infantile mastoid is involved, he will find a denser outer wall and a relatively thin inner wall at operation. Clinically several possibilities must be considered. The condition may clear up spontaneously; it may travel backwards, breaking through the inner wall into the posterior fossa of the skull; it may enter the labyrinth causing internal ear disturbance; or it may remain in the antrum causing destruction of the lining membrane and ossicles, resulting in chronic otitis media with possible formation of cholesteatoma.

Cholesteatomatus formation occurs most frequently in the region of the antrum and less often in the mastoid process. Ballance[6] states that it may extend into the cranial cavity or internal ear in rare instances.

In acute fulminating mastoiditis, cell outline is lost early and the region becomes quite dense. Later on, destruction may be shown by the appearance of a radiolucent area with loss of cell outline, but this occurs after the lymphatics have cleared away the debris.

In the uncomplicated case, after the acute symptoms have subsided, and the reparative process begins, we find the deposition of lime salts in the region formerly occupied by cell structure, the radiograph now giving the usual picture of sclerosed mastoid.

When infection occurs in the middle ear there is always an outpouring of serum, if not an extension of the inflammatory process into the mastoid cells. This instead of giving normal distinct cell outline gives a diffuse clouding, and follows the infection within a few hours, but may clear up entirely without causing any symptoms referable to the mastoid. Lange[7] speaks of this type as a first degree mastoiditis.

In the second degree mastoiditis, the cell outline is more hazy over the entire distribution and there is, perhaps, at some point in the posterior superior angle of the temporal bone, or in the body of the mastoid process, an area in which the cell outline is lost completely, and in its place appears a white blur. This suggests a destruction of cell outline due either to infection or interference in blood supply. It is not until the lymphatics have begun to clear away the débris that we have an area of diminished density indicative of a process of at least some days' standing.

When destruction of cell outline is general, as invariably happens once a mastoid has begun to break down, the process is said to have reached the stage of third degree mastoiditis.

At any time during the second or third stage of destruction, the inner cortex may become eroded and an abscess form about the lateral sinus. In a certain percentage of cases this condition can be made out on the radiograph as loss of bone structure.

It is not possible to make out subdural abscess or sinus thrombosis as such, although it may be possible to make out the presence of pathology in this area as shown by the destruction of more dense bony structure.

When destruction of the mastoid cells is complete and the infection has subsided, replacement by bone begins. The new tissue can be made out at the periphery of the area of destruction; in some instances it can be made out as early as the end of the first month and may not be complete for several months. The new bone is denser than the surrounding normal bone and has none of its finer texture. This is the sclerosed type of mastoid.

The radiograph is of its greatest value in the course of an acute otitis media developing mastoid symptoms, where the otologist is gathering together his clinical and laboratory findings in order to determine the proper procedure. If the clinical signs are acute and unmistakable, but the radiograph shows no destruction, it would be unwise to wait for this pathology to be demonstrable, for by so doing serious complications may arise.

CONCLUSIONS

1. The best detailed plate possible should be obtained for interpretation of mastoid pathology.

2. A knowledge of the variation in the anatomy as seen radiographically is essential.

3. The complete clinical history and physical findings should be known before an opinion is given.

4. An acquaintance with the possible course in infections of the middle ear is of great aid in interpretation of mastoid radiographs.

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HEAD-REST FOR THE ROENTGENOGRAPHY OF THE ACCESSORY SINUSES*

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Successful roentgenography of the accessory sinuses of the head depends largely upon the carefulness with which the head is adjusted and the tube centered so that the central rays go through the head at the proper place and at the proper angle. Every roentgenologist who is at all careful always uses some instrument of precision in order to indicate the angle of divergence from the base line of the skull along which he projects the central rays. The straightening up of the head to prevent sidewise rotation is usually done by guesswork. Dr. George E. Pfahler presented an instrument to accomplish this purpose at one of the midwinter meetings of Eastern Roentgenologists. The description of this instrument was published in The American Journal of Roentgenology for April, 1917.

The author has devised a head-rest which accomplishes both purposes described; that is, it indicates the proper angle to direct the central rays, and also prevents sidewise rotation of the head. If the head is rotated to one side, the shadow of the petrous portion of the temporal bone on the opposite side is projected into the maxillary sinus. Also, the rays do not go directly through the ethmoid cells, which has the effect of widening the shadow of the ethmoids on one side and narrowing it on the other. If the sidewise rotation is of any considerable degree, the entire maxillary sinus will be blotted out by the shadow of the petrous portion of the temporal bone, and unless the observer is quite familiar with the interpretation of sinus negatives, he may think that this is due to an accumulation of pus in the maxillary sinus. It is not unusual to have a marked lack of symmetry in the two sides of the head and face, and it is often very difficult to judge whether the head is rotated sidewise by looking at it. Further difficulty is encountered in women with long and fluffy hair where the shape of the head cannot be accurately made out.

In order to overcome this, we have devised the head-rest shown in the illustration. This consists of a block of wood such as is very commonly used to rest the head on in making sinus roentgenograms. The angle of the block is 30 degrees from the horizontal. A square metallic upright projects from the face of the block near the upper border. The upright is accurately placed so that it projects at right angles to the face of the block. This is important, since if it is not so placed, the head-holder which slides up and down on this upright will not be parallel to the surface of the block.

The apparatus to level and to hold the head consists of a semicircular bar of metal with a square hole through the middle of the semicircle by means of which it fits on the square upright and allows up and down adjustment. The plane of the semicircle is parallel to the surface of the block. Projecting inward through round holes cut in each free end of the semicircle are two rods terminating in small brass balls. These rods are adjustable and can be fixed by thumbscrews. The entire semicircle is also adjustable on the square upright and can be fixed by a thumbscrew. Lateral rotation of the semicircle is of

* Read at the Midwinter Meeting of the Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 28, 29, 1921.

course impossible, as the square hole in the semicircle fits accurately over the square upright.

The method of operation of this head-rest is as follows:

The apparatus is placed on a table, or some other level surface, and the patient either lies or sits with the forehead against the surface of the block. The metallic semicircle is adjusted on the square upright until the rods

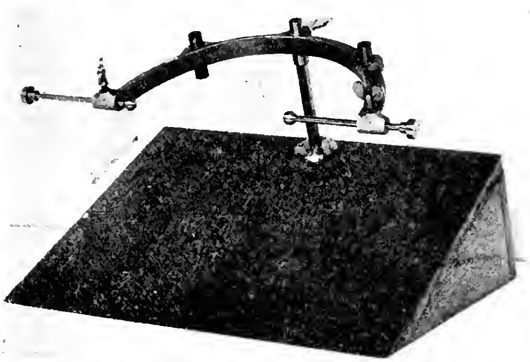

Fig. 1. Head-rest for radiography of the accessory sinuses.

with the brass balls come opposite the external auditory meatus on each side. The rods are then adjusted so that the balls are placed in the external auditory meatus on each side. The thumbscrews are tightened and the head held accurately in this position. Since the metallic semicircle is parallel to the surface of the plate, which in turn has been placed on the surface of the wooden block, the distance from the plate to the brass ball on each side will be the same. As the brass ball has been placed in the external auditory meatus, therefore the distance from each external auditory meatus to the plate will be the same, and if this condition obtains, the head will not be rotated from side to side.

A small right-angled triangle of celluloid or aluminum is fastened between the small brass ball and the rod on one side by passing the rod through a hole drilled in the right angle of the triangle so that the triangle is perpendicular to the rod and the measuring angle points downward. This triangle is used to find the base line of the skull and indicate the proper angle for the central ray. The brass ball being in the external auditory meatus, the rod is rotated until the altitude of the metallic angle corresponds to the base line of the skull—that is, to a line drawn from the external auditory meatus to the glabella. The hypotenuse of the triangle then indicates the direction of the central ray. In practice, I have cut this metallic triangle at 30 degrees and in addition to this, have placed a strip of adhesive plaster across it to indicate to me also an angle of 23 degrees, and in using the apparatus I make one exposure at each angle. I believe this procedure has been of certain advantage. The angle desired can, of course, be marked out on the metallic triangle without interfering with the accuracy of the instrument.

Contrary to expectations, the use of the apparatus has not occasioned any particular discomfort to patients. It is not difficult to adjust and its use has been a great help to me. The apparatus would be improved by making a tunnel in the wooden block so that more than one exposure could be made without moving the patient's head and thus changing the adjustment.

A TABLE DESIGNED FOR THE SIMPLIFICATION OF PNEUMOPERITONEUM TECHNIQUE

By L. R. SANTE, M.D.

Assistant Professor of Radiology, St. Louis University Medical School;

Radiologist to St. Louis City Hospitals

ST. LOUIS, MISSOURI

EARLY in our experience with pneumoperitoneum, we were confronted with the problem of sécuring a technique which, while rapid, would still be sufficiently thorough so as not to miss any important pathological lesions. One of the greatest drawbacks to the more universal use of pneumoperitoneum is the great number of positions in which the patient must be placed in order to secure a view of all the intra-abdominal organs from all aspects.

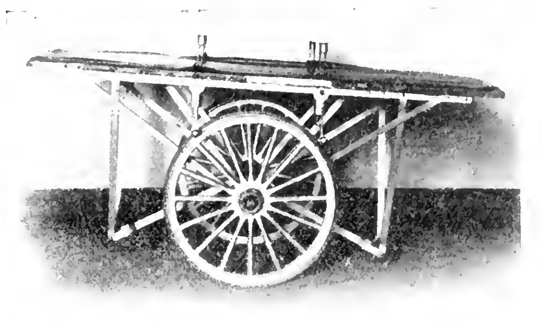

FIG. 1. This table, mounted upon two central wheels, may be tilted readily, the head being raised or lowered by pressure on either end. Two kidney elevators, operating independently, extend through the table top and permit elevation of the patient to any desired level.

FIG. 2. Elevators in position supporting patient under chest and thighs, taking pressure off of the abdomen and allowing the abdominal wall to sag freely forward, permitting examination in the retroperitoneal position.

In the earlier German articles many different positions have been described. Rautenberg[1] in 1914 described the findings in the standing and left lateral positions, and in a later communication of the same year[2] described the appearance in the dorsal and Trendelenburg positions.

Goetze[3] in his paper on pneumoperitoneum gives a summary of the positions previously utilized and goes into considerable detail as to the positions which he considers of greatest importance. He examines patients in the dorsal, standing, both lateral, knee chest and Trendelenburg positions. Early in 1919, Drs. Stewart and Stein in their initial article[4] outlined in great detail five positions with which they felt a thorough examination of all intra-abdominal organs could be made. These positions are briefly:

1. Prone: the tube above, plate beneath abdomen; to give a clear view of the diaphragm, liver, spleen, gall-bladder.

2. Lateral position, with the patient lying on either side to show the clear outline of the kidneys and lateral view of the liver and spleen.

3. A similar lateral view with hips elevated, the patient on either side, tube behind, plate in front; to show the kidneys and lateral view of the pelvic organs. (Fig. 4.)

4. An anteroposterior view with one end of the table elevated, patient prone, with tube beneath and plate above. This position is described as the best for the demonstration of the pelvic organs. (Fig. 3.)

5. The dorsal position, the patient upon his back, plate on one side and tube upon the other, the ray being directed from side to side. This position is the best for abdominal adhesions.

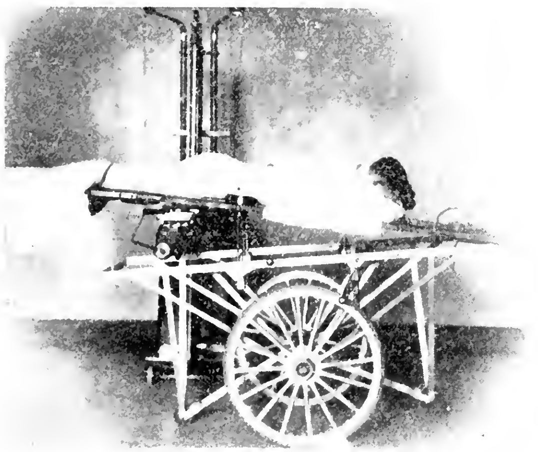

Fig. 3. By inserting a pin, these elevators may be used to raise the entire top of the stretcher at either end to any degree, permitting examination with the tube beneath the table, described by Drs. Stewart and Stein as best for pelvic organs.

Another position for the examination of the retroperitoneal space and for the detection of retroperitoneal masses, was described recently by the author.[5] This consists in supporting the patient in a prone position (Fig. 2), one support beneath the chest and one under the thighs, allowing the abdominal wall to sag freely forward, and thus taking all pressure off the intra-abdominal organs. The intestines and all organs with mesenteric attachment fall downward, leaving the retroperitoneal and prevertebral space clearly visible.

An effort to secure the many positions necessary for pneumoperitoneum is evidenced by the ingenious table constructed for that purpose and described by Orndoff. This table provides for the tilting of the patient at various angles, and the simultaneous movement of the tube and screen so as to examine the patient from all viewpoints. Its very elaborateness and expense are the chief points against its general adoption.

The table which we have adopted for this purpose (Fig. 1), and which while very simple and inexpensive has been very satisfactory, can be briefly described as an ordinary hospital stretcher mounted upon two central wheels, having a shorter support at either end, which allows about eight inches' tilt at the head or foot. Thus by mere pressure on either end of the cart the head of the patient may be either raised or lowered. To this we have added two ordinary kidney elevators of the type commonly found on operating tables, the elevating tracks of which extend through holes in the top of the stretcher and permit elevation of the patient to any degree necessary; one support raising the chest, the other the thighs of the patient, allowing the abdomen to hang freely and permitting examination in the retroperitoneal position. (Fig. 2.)

By inserting a pin these elevators may be used to raise the entire top of the stretcher at either end to any degree—permitting examination with the tube beneath the table, described by Drs. Stewart and Stein as best for pelvic organs. (Fig. 3.)

The other positions are quite obvious. The patient may be inflated while on his back

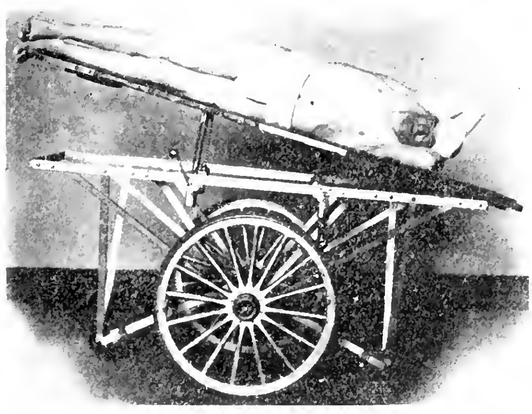

Fig. 4. A lateral view with hips elevated, the patient on either side, tube behind, plate in front; to show the kidneys and lateral view of pelvic organs (Stewart and Stein).

with his head sufficiently lowered by pressure on the upper end of the cart. He can be inflated while under the fluoroscope by rolling the stretcher before the ordinary vertical fluoro-

scope. The dorsal and right and left lateral positions are secured by having the patient roll first on one side then on the other before the vertical fluoroscope. The entire top of the stretcher is not attached in any way and can be transferred by two assistants with the patient in place to the horizontal fluoroscope. (Fig. 5.)

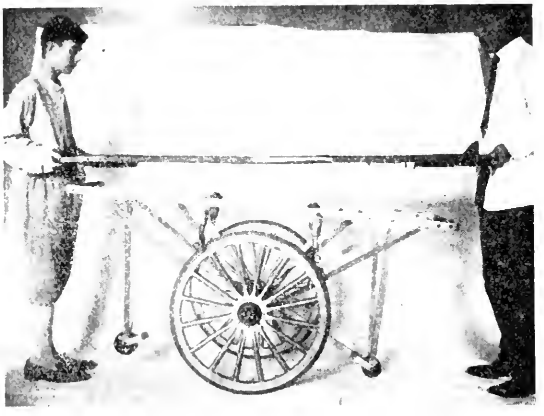

Fig. 5. The entire top of the stretcher is not attached in any way and can be transferred by two assistants, with the patient in place, to the horizontal fluoroscope.

It will be seen then that this stretcher, though simple of construction, will permit fluoroscopic or radiographic examination in all of the pneumoperitoneal positions so far described. The stretcher is not bulky or inconvenient, and when not in use for this purpose can be used for an ordinary stretcher or exposure table. A stretcher of essentially this same construction has been used by us for pneumoperitoneal examinations for the past year with complete satisfaction.

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5. Sante, L. R. The detection of retroperitoneal masses by the aid of pneumoperitoneum, Am. J. Roentgenol., March, 1921, viii, 129-134.

THE USE OF RADIUM IN THE TREATMENT OF MYXOMATOUS NASAL POLYPS

PRELIMINARY REPORT

By H. R. LYONS, M.D.

Section on Oto-Laryngology and Rhinology, Mayo Clinic

ROCHESTER, MINNESOTA

My regret to find that the rapidly recurring type of myxomatous nasal polyp does not always respond to medical treatment or surgical measures, led me about two years ago to use radium postoperatively.

Notwithstanding personal advice and literature on the subject to the contrary, nasal polyps frequently recur very soon after their removal surgically. The records in our department show that innumerable cases of nasal polyp have not responded favorably to surgical measures even in the hands of competent rhinologists. One reason that the operative results are not always satisfactory is that the polyp has not a definite pedicle attached to the mucous membrane of a turbinate or a sinus. Removal of this tumor and its pedicle and the nearby tissue or cells does not eliminate the condition, because the adjacent tissue is also undergoing a myxomatous change, which will soon appear in the form of a polyp. The changed area of mucous membrane around the polyp may extend a considerable distance away from the pedicle. It seems, clinically, that surgery in some instances stimulates the formation of polyps in this adjacent tissue.

The polyp which recurs after the removal of a myxomatous tumor which is attached either to a turbinate or involves the ethmoid cells is also of a myxomatous type and frequently is a larger growth than before the operation.

THE ACTION OF RADIUM

It is well known that radium stimulates the production of fibrous tissue, and this action is utilized in the treatment of myxomatous polyps. After one, two, or three treatments by radium, the primary myxoma recurs as a fibromyxoma or a fibro-adenomyxoma. This type of polyp is very much more satisfactory to deal with than is the myxomatous type.

It must be emphasized, first, that radium inserted, for example, into a large solitary nasal myxoma will not cause such a tumor to disappear, nor will it change the type of the tumor; second, radium postoperatively does not prevent the recurrence of a polyp; and third, the use of radium in treating myxomatous polyps associated with a local suppurative process does not cure the latter.

APPLICATION

A hypothetic case illustrating the treatment by and action of radium on myxomatous nasal polyps is as follows: A patient presents himself because of constant nasal obstruction. He gives a history of having consulted a rhinologist four years before, who operated on his nose, removing large masses of jelly-like polyps. He was greatly relieved for a short time, but the obstruction returned and operation for large masses of polyps was again necessary six months after the diagnosis was first made. He has had a total of seven operations for nasal polyps.

Examination reveals a large mass of multiple polyps in the right middle meatus. The polyps are jelly-like and very soft; they appear "water-logged." A specimen is sent to the pathologist, who reports myxomatous polyp tissue. The patient is advised that one or more operations are necessary, and that radium treatments will be used.

A radical operation for the removal of

the polyps is performed and all the polyps are removed with a considerable amount of the adjacent tissue which is not frankly myxomatous, but which, as experience has taught, rapidly recurs as such. As soon as the reaction diminishes, from three to six days postoperatively, radium treatment is given and the patient is kept under observation. Soon some very pale tissue in the middle meatus, not quite healthy in appearance, is noted. Within the next week or two this tissue becomes frankly polypous. Local treatment is continued. In case of recurrence in the remaining tissue a section is sent to the pathologist who reports fibromyxomatous tissue. A second operation, not so extensive as the first, is performed. The fibromyxomatous tumor which resembles a fibroma malle is removed surgically much more satisfactorily than the primary tumor. If the recurrence is extensive the second operation is followed in from three to six days by a second radium treatment; a third treatment is rarely found to be necessary.

DOSAGE

In my early cases I used a 25 mg. tube of radium, screened with a silver tube covered by a sterile rubber finger cot for one hour. Experience gradually eliminated my fear of a burn and indicated that larger doses were necessary. I now use a 50 mg. tube for two hours. Subsequent treatments are given with an interval of one week. The radium tube is put in the region of the myxomatous tissue and made secure by packing with sterile vaseline gauze. The string tied to the radium tube is attached to the cheek by a piece of adhesive tape. After two hours the pack and radium are removed. The reaction resulting from this treatment is not apparent for forty-eight hours or more. In fourteen cases treated with 25 mg. or 50 mg. for two hours no burns occurred.

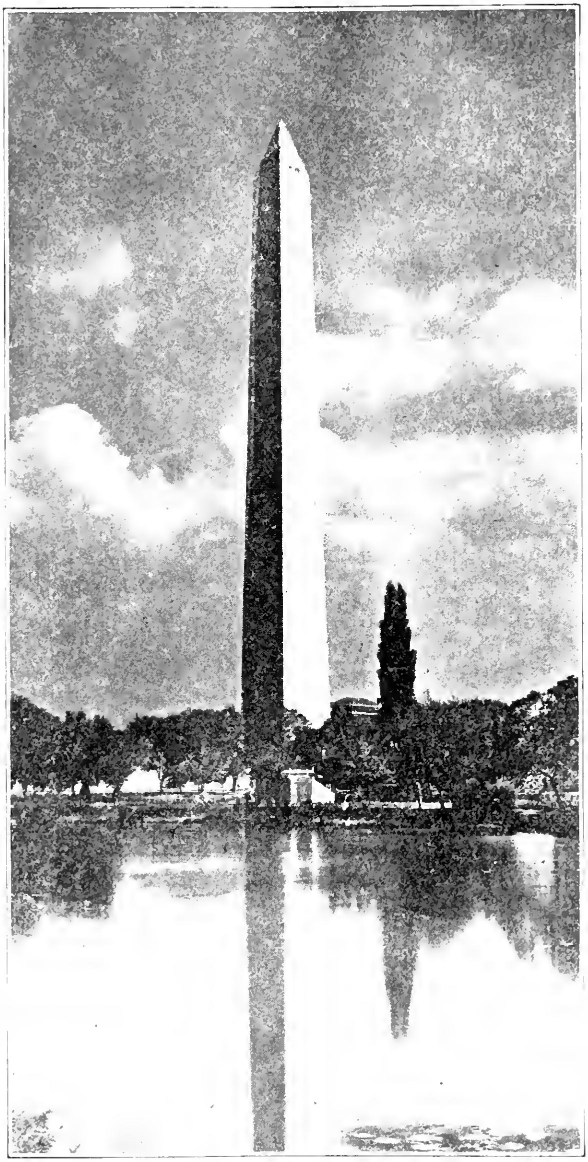
Conclusions regarding postoperative radium treatment await the test of more time and more experience. I believe, however, that in the stubborn cases of myxomatous nasal polyps, especially those recurring after operative measures, the treatment will result in a change from a myxomatous type to a fibromyxomatous type in which operation may be more successfully performed. Also the polyps recur less rapidly with radium treatment and thus the interval of relief is lengthened.

The detailed report of fourteen cases treated postoperatively since November 1, 1918, will be submitted later.

Washington, the capital city of the greatest republic in the world, is universally conceded to be truly the "City Beautiful." It stands alone, not only among American cities but among the capitals of the world, in the noble simplicity of its original design, its spaciousness, its rapid and orderly growth, and its combination of natural and architectural beauty, enhanced by the highest perfection of landscape gardening.

The city has more than six thousand acres of public parks and reservations. Along its hundreds of miles of streets, ranging in width from 80 to 120 feet, over 105,000 shade trees have been planted, a large proportion of which are in their full growth and luxuriance.

Washington probably has a greater variety of trees, both indigenous and foreign, than any other city in the world, but only seven species are now used. The American elm, the linden, the sycamore, the red and pin oak, the sugar maple and the ginkgo—the first three on the wide avenues, the oaks and maples in many streets and the ginkgo in the narrow streets. These are all grown from seeds from the old trees, sown in greenhouses, and when they have reached the height of 18 to 24 inches they are set out in rows in the government nurseries and later transplanted.



Washington Monument

The City of Washington and the District of Columbia are co-extensive and comprise an area of 69,245 square miles. The population is rapidly nearing the half-million mark.

On September 9th, 1791, three commissioners appointed by President George Washington decided that what is now Washington, D.C., should be named "City of Washington in the Territory of Columbia;" also that "the streets be named alphabetically one way and numerically the other, the former to be divided into north and south, and the latter into east and west numbered from the Capitol."

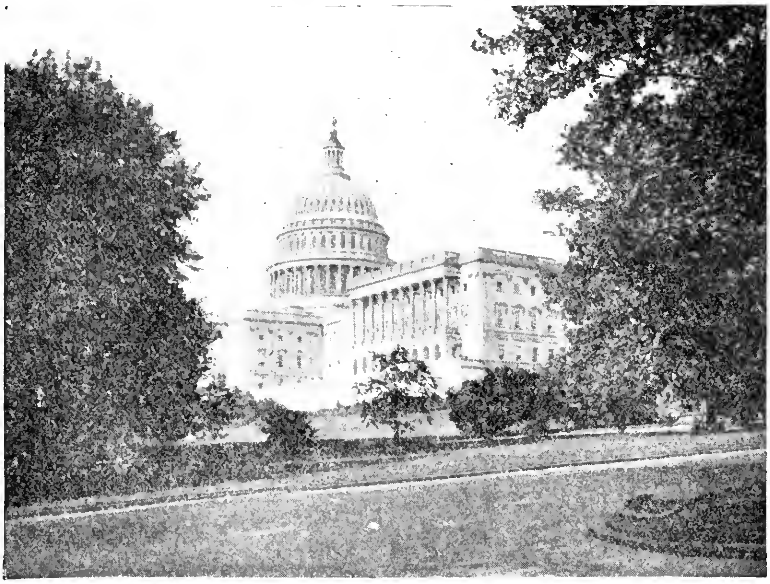
A thousand tourists enter the city every day. No one can fail to be impressed by the great portal of the city, the solid granite Union Railway Station, with its vast passenger concourse, 760

feet long, the largest room in the world under one roof. Trains from North and East, from South and West, all enter this station, the latter through twin tunnels which pierce Capitol Hill many feet below the surface of the street. Should it be the traveler's good fortune to arrive while it is still day he will note the magnificent dome of the Capitol immediately ahead, and to the left the gilded crest of the Library of Congress beckoning a silent welcome, while immediately to the right and connected with Union Station is the City Post Office.

In the distance, towering against the sky, rises the Washington National Monument, a white marble shaft 555 feet 5⅛ inches in height, which greets the visitor from many different points. An ascent to the top will repay one with a most entrancing panorama of the city, the Potomac River, and even many distant places of interest in the States of Maryland and Virginia.

Washington is naturally the home of numerous embassies and legations. The White House, facing Jackson Square at the foot of Sixteenth Street—which is generally spoken of as the Avenue of the Presidents—marks the beginning of imposing edifices extending north for more than two miles, among which may be noted the official homes of the representatives of Great Britain, Italy, Argentina, Cuba, Paraguay, Siam and many other nations.

The city occupies a rather unique position in that it does not encourage industrial pursuits. As the capital of our nation it has ever been considered the central arena of the United States governmental machinery from which the Federal workshops of the various departments direct the activities of the nation. It was, therefore, quite fitting that factories and other unnecessary enterprises be restrained. The Engineer Commissioner of the District of Columbia, an officer of the War Department, appointed by the President of the United States, constantly guards the capital against architectural vandalism and industrial sabotage. It was never intended by its founders to be a populous city. It was to be essentially a political city—a city of government, with the government idea dominating and pervading everything. Its unique and single mission was to be preserved through the centuries, absorbing all splendors and all renown to the glory of the government.

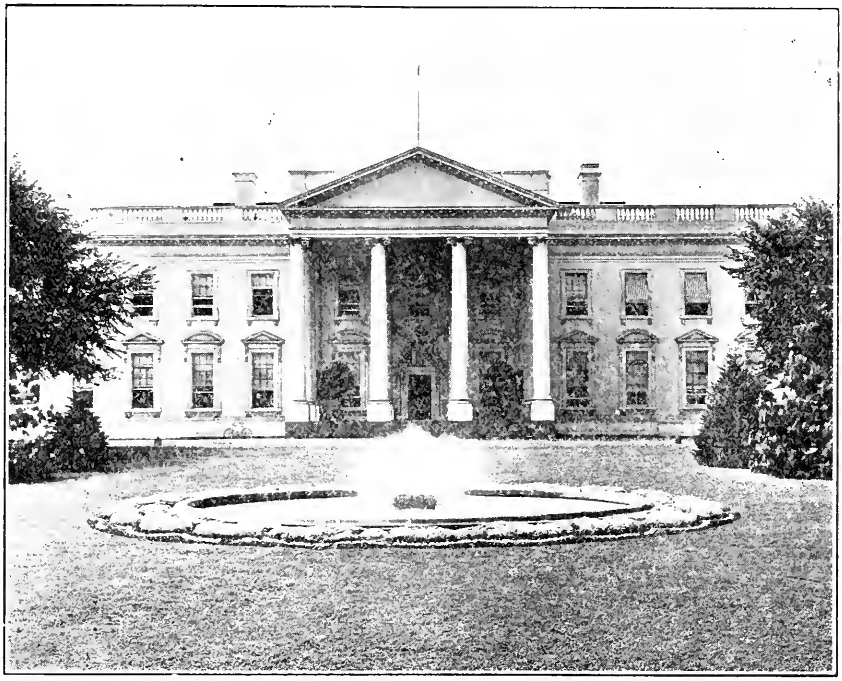


The Capitol seen through the trees.

Thus it was to be preeminently the people's city—with every citizen holding the loyal and tender tie of part ownership in all that made it great—in stately buildings, and in fair repute, and sharing with every other citizen his pride in the capital of our common country.

As an educational center Washington ranks second to none. Among prominent institutions of learning are included George Washington University, Georgetown University and Howard University. Another, most interesting, is Columbia Institute for the Deaf, also known as Kendall Green, because in 1856 Amos Kendall gave his home to educate the deaf people of Washington. To-day it contains 153 acres, twenty-eight in beautiful green lawns with fine shade trees, thirty-five in farmland and forty in woodland, together with a large athletic field.

The student here finds ample opportunity to pursue his studies under excellent conditions, for the best libraries of the world are found in the nation's capital. The Library of the Surgeon-General's Office in the building of the Army Medical Museum, contains the largest and most complete collection of medical books in the world, and its Incunabula are second only to those of the British Museum in London. Among other libraries available for reference are the Congressional Library, the Carnegie Library, the Library of the Smithsonian Institute, and many others connected with the various departments of the United States Government.



The White House.

In the arrangement of charitable organizations and well equipped hospitals the capital has just reason to be proud. That ample provision for the indigent sick has been anticipated is evidenced by the splendid buildings, grounds and equipment of the Washington Asylum Hospital, the Children's Hospital, and the gigantic Hospital for the Insane, St. Elizabeth's, just across the eastern branch of the Potomac. Many smaller hospitals abound, all adding to the general scheme for efficiency and beauty, and at the terminus of Sixteenth Street the Walter Reed Hospital is most suitably located near the woods and streams of Rock Creek Park.

And here we find the Home of the Medical Society of the District of Columbia, of which the local physicians are justly proud, many modern high school buildings, the imposing municipal building, public fountains, private and municipal swimming pools and a magnificent bathing beach, and many other points of interest worthy of comment and praise did time and space permit their connotation.

Mount Vernon.

Washington hostelries have long been noted for excellence of service. Among the oldest and perhaps the largest are the Raleigh, the New Willard, the Shoreham, and the New Ebbitt, all centrally located, and many others readily accessible. The site of the Raleigh was formerly occupied by the Kirkwood Hotel where Vice-President Johnson was living at the time Lincoln was assassinated in the Ford Theater and Seward was stabbed at his home where the Belasco Theater now stands, and an attempt was made the same night to assassinate Vice-President Johnson. The newest and probably the most modern is the Washington Hotel, situated on Pennsylvania Avenue, opposite the Treasury, where arrangements have been perfected for the meeting of the American Roentgen Ray Society to be held on the ground floor. The great assembly hall is undoubtedly the most spacious ever offered (6,500 square feet) and immediately adjoining will be the registration booths, while across the hall are the grill and buffet, where the commercial exhibits will be held. Special rates have been secured for members and friends of the Society.

Among places to be visited by those interested in radium is the National Bureau of Standards, the official home for the standardization of weights and measures. Here radium is weighed and tested before it is finally distributed. The buildings and grounds are situated like a "city built upon a hill," sufficiently removed from human habitation to escape extraneous influences that might deflect the most sensitive measuring devices.

Potomac Drive Way, sometimes erroneously designated the "speedway," is built upon land reclaimed along the banks of the Potomac. Here, in addition to walks, flower gardens, golf links, tennis and polo grounds, are the municipal vegetable gardens, arranged and neatly plotted, free to all.

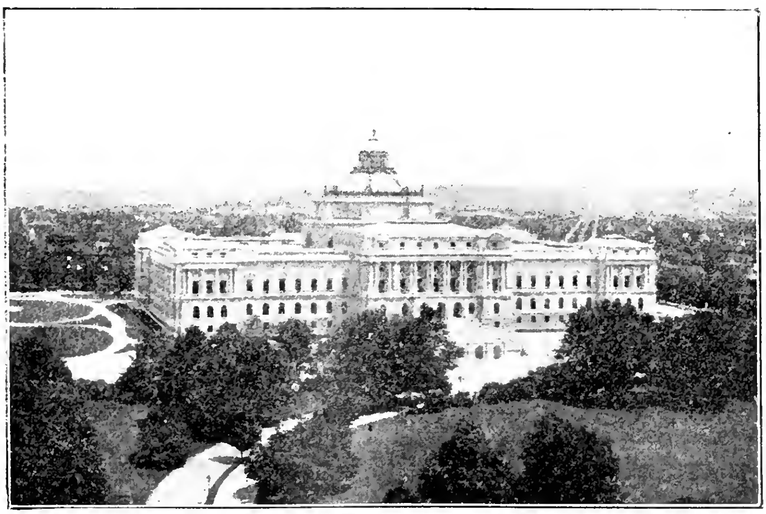
Many visitors are not aware that, east of the Mississippi River, the great falls of the Potomac are second only to Niagara. Great

Falls is situated fifteen miles north of Washington, and is reached by motor or electric railway. A magnificent series of cascading avalanches forms a drop of 80 feet within a distance of a few hundred yards, carrying over its final precipice a tremendous volume of water.

Sixteen miles below Washington, most picturesquely situated on the right bank of the Potomac, is Mount Vernon, the home of George Washington. Here the First American sleeps in his hallowed tomb and pilgrims gather from every nation and pay tribute to his memory in words or deeds or flowers. The approach by the river, made possible through a well arranged steamship line with regular schedule of trips, lends enchantment to the view, emphasizing the dignity of the mansion with its spacious trees and grounds 125 feet above the landing wharf. Many priceless relics associated with Washington during his life may be viewed there.

Martha Washington's garden, just back of the mansion, with its quaint boxwood hedges set out more than a century and a half ago, is still intact. Some of the plants have lived until now, and there remains to this day a beautiful rose bush, blossoming every year, which was planted by Mrs. Washington, and named the Mary Washington Rose by George Washington himself, in honor of his mother. There is perhaps no more delightful recreation or more instructive relaxation than an outing down the river crowned by a visit to the home of the Father of our Country. Those who prefer to make the trip via the all-rail route of the electric trains may avail themselves of stop-over privileges at Alexandria, eight miles from Washington, and visit Carlyle House and other places of interest, all open to visitors. The round trip by this line may be made in three hours, allowing one hour and twenty minutes on the Mount Vernon grounds.

CHARLES A. PFENDER.



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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

TWENTY-SECOND ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY, SEPTEMBER 27, 28, 29, 30, 1921

Published herewith is a provisional and still incomplete program of the Annual Meeting.

As previously announced, the first day of the meeting will be given entirely to papers on therapy with the exception of a short executive session in the forenoon.

Members whose names are not on the provisional program, and who have papers that they wish to present at this meeting will please communicate with the President at an early date, sending the subject and a short abstract of the paper. There is still room on the program for papers of importance.

Executive Sessions.—It is especially important to have a large attendance of members of the Society at the Executive Session to be held on Wednesday afternoon, September 28. Matters of vital importance to the Society will be considered.

Lantern Slide Exhibit.—Space has been reserved and racks will be provided for large plate exhibit. It is hoped that members will give special attention to this. The educational value of a good plate exhibit, especially to younger roentgenologists, can hardly be overestimated. Photographs, photo-micrographs, and statistical charts illustrating the results of roentgen and radium treatment will add to the value of the exhibit.

Plates, films, and other material for the exhibit should be securely packed and shipped to Major H. C. Pillsbury, M.C., U.S.A., Army Medical, 5th and D Streets, Washington, D. C., to arrive not later than September 10.

Local Entertainment.—Dr. Charles A. Pfender is Chairman of the local committee which will provide entertainement for the ladies and other guests of the Society. Adequate plans are being made for the comfort and enjoyment of all who attend the meeting.

Annual Banquet.—The annual banquet will be held on the evening of Thursday, September 29. It is planned to make the banquet of quite unusual interest this year.

Provisional Program

Cancer of the Uterus. Henry Schmitz, M.D., Chicago.

Treatment of Cancer of the Cervix. E. A. Merritt, M.D., Washington.

Treatment of Brain Tumors by Radiation. Henry K. Pancoast, M.D., Philadelphia.

Progress of Deep Roentgen Therapy. (The Caldwell Lecture.) Dr. Réné Ledoux-Lebard, Paris, France.

Symposium on Therapy of the Thyroid Gland

Radiotherapeutics of Hyperthyroidism. George W. Holmes, M.D., Boston.

Radiotherapy of the Thyroid. A. F. Tyler, M.D., Omaha.

Treatment of Carcinoma of the Thyroid by Radiation. G. E. Pfahler, M.D., Philadelphia.

The Roentgen Ray in Dermatology. George W. MacKee, M.D., New York City, and Henry H. Hazen, M.D., Washington. (Dr. MacKee will discuss the importance of roentgenology in dermatology, the dermatologist and the radiologist, fractional versus intensive treatment, filtered versus unfiltered radiation, idiosyncrasy, medico-legal aspects. Dr. Hazen will cover the treatment of various skin diseases by radiation.)

The Present Status of Deep Roentgen Therapy in Europe, from a clinical standpoint. W. H. Stewart, M.D., New York City.

Therapy of Superficial Growths. Charles F. Bowen, M.D., Columbus, Ohio.

Estimation of the Skin Dosage in Diagnostic X-Ray Work. Arthur W. Erskine, M.D., Cedar Rapids, Iowa.

The Iontoquantimeter in Measuring Dosage for Deep Therapy. Reginald Morton, M.D., London, England.

New Technique for the Vertical Examination of the Sphenoid with Demonstration of the Film Holder. George E. Pfahler, M.D., Philadelphia.

The Stereo-Fluoroscope. James D. Morgan, M.D., Montreal. (Dr. Morgan's stereofluoroscope will be demonstrated under actual working conditions.)

Papers or addresses will be given by W. D. Coolidge and J. S. Shearer on subjects not yet announced.

Pericardial Adhesions. Edwin C. Ernst, M.D., St. Louis.

Paget's Disease; Roentgen Studies Relating to its Etiology and Differential Diagnosis. Leon T. LeWald, M.D., New York City.

Symposium on Education in Roentgenology

Undergraduate Education. F. H. Baetjer, M.D., Baltimore, and H. K. Pancoast, M.D., Philadelphia.

Graduate Education. George W. Holmes, M.D., Boston, L. Jaches, M.D., New York City, and J. S. Shearer, Ithaca, N. Y.

Gastro-enterostomy, Bad After-Effects. A. H. Pirie, M.D., Montreal.

The Present Status of Pneumoperitoneum as a Diagnostic Aid. James T. Case, M.D., Battle Creek, Mich.

The Diagnosis and Removal of Foreign Bodies from Bronchus and Esophagus. Charles F. Bowen, M.D., Columbus, Ohio.

Pulmonary Tuberculosis. L. Jaches, M.D., New York City, and H. Wessler, M.D., New York City.

Benign and Malignant Ulcers from the Roentgenologic Viewpoint. Russell D. Carman, M.D., Rochester, Minn.

Calcification in the Meninges of the Brain. H. M. Imboden, M.D., New York City.

Dental Radiography in the Light of Clinical and Pathological Findings. Allan Scott Wolfe, D.D.S., Washington.

Diagnosis of Internal Derangements of the Knee Joint. Arial W. George, M.D., Boston.

(Subject not yet received.) Willis F. Manges, M.D., Philadelphia.

X-Ray Treatment of Diphtheria Carriers. P. M. Hickey, M.D., Detroit.

Demonstration of Simplified X-Ray Unit for Treatment of Tonsils and Adenoids, Exophthalmic Goiter, Tubercular Glands of the Neck, and Enlarged Prostate. W. D. Witherbee, M.D., New York City.

(Subject not yet received.) J. W. Pierson, M.D., Baltimore.

(Subject not yet received.) Walter Mills, M.D., St. Louis.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of THE AMERICAN ROENTGEN RAY SOCIETY. Mr. A. Gumpert, Manager of The New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him. It is especially recommended that hotel reservations be made as early as possible.

A NOTE ON THE BUCKY-POTTER DIAPHRAM

At the annual meeting at Minneapolis last September Mr. Wilsey read a paper on scattered radiation and described the method he used for measuring the relative amounts of scattered and direct radiation responsible for the formation of the photographic image. it will be recalled that in the average negative of a thick part covering a fairly wide area (for example, a twenty inch circle) the image-forming rays are only 17 per cent of the total radiation making the picture. The other 83 per cent is scattered radiation.

It is to be regretted that the impression has been somewhat general, since the introduction of the Bucky diaphragm, that this apparatus marks the beginning of a millennium in the making of *x*-ray negatives, absolutely cutting out scattered radiation, whereas its function at best is but to reduce the volume of scattered radiation, hence causing the image-forming radiation to become more effective. The average type of Bucky diaphragm that has been introduced will change the ratio of scattered to image-forming radiation from about 83 and 17 to about 50 and 50, or possibly 65 and 35, or something of that order. Of course this means an increase in the time of exposure.

Mr. Wilsey's paper gives a method which may be readily used for measuring the relative amounts of scattered and direct radiation striking the plate, and it will be a simple matter for anyone interested to make a qualitative test without any additional apparatus other than a small lead cylinder. It is this ratio which determines the effectiveness of any Bucky diaphragm, for the greater the amount of scattered radiation cut out, the greater the time factor. In the average Bucky-Potter diaphragm on the market this time factor is about 3; that is, the exposure with the diaphragm is four times what it is without it, other conditions being the same. If the factor is much less than 3, the diaphragm cannot be effective.

There has been of course some disappointment and criticism since the present Bucky diaphragms have been introduced, but it is the writer's feeling that this has been a good thing for this science, for the manufacturers have had the benefit of a vast amount of constructive criticism as well as a certain wholesome amount of destructive criticism. This will no doubt lead eventually to mechanically perfect diaphragms, for undoubtedly a good deal of the objectionable "corduroy" effect shown in some diaphragmed negatives, due to picturing the grid structure, is caused by lack of uniformity in motion of the grid.

It should also be borne in mind that the efficiency and desirability of any diaphragm of this sort can best be determined by remembering that it is most useful for the raying of thick subjects. There is no desirability of using it for raying thin parts or probably even for raying the thicker parts of an average sized patient, but when the subject is from ten to fifteen inches in thickness, then of course the ratio of scattered to direct radiation is considerably changed and the effectiveness of the Bucky diaphragm is increased.

It is the writer's opinion, then, that the desirability of installing the Bucky diaphragm is a matter to be decided by the individual. It will depend entirely upon the volume of cases requiring radiation of the thicker parts or perhaps abnormally thick parts, and if it is decided that one can be used effectively, then the prime consideration in buying it should be its mechanical perfection.

Millard B. Hodgson
Rochester N. Y.

WESTERN SECTION A. R. R. S. REPORT OF ANNUAL MEETING

The Second Annual Meeting of the Western Section of the American Roentgen Ray Society, held at Portland, Oregon, May 27, 1921, brought forth a very gratifying expression of interest in attendence and exhibits. The roentgenologists of Oregon and Washington attended in force, while Califor-

nia was represented by nine delegates. Men from Arizona, Idaho and Montana were also in attendance, bringing the total representation up to about forty. This is an excellent showing, as it comprises about one third of the roentgenologists in the Western Section. The Section joined with the Pacific Coast Roentgen Ray Society in this meeting, and this latter organization took charge of the program on the second day of the meeting, May 28th.

The two organizations were entertained by the Portland Roentgen Club. They were banqueted, dined, and given a four-hour ride over the famous Columbia River Highway—all at the expense of this club of about a dozen members.

The programs were of a high order of excellence, as the papers which will shortly appear in this JOURNAL will demonstrate. The Section received with great enthusiasm the information that THE AMERICAN ROENTGEN RAY SOCIETY will probably come to the Pacific Coast for the 1922 meeting. Plans are already being made for the proper entertainment of the Society in a manner commensurate with its dignity and scientific character.

W. WARNER WATKINS, Secretary

MIDYEAR MEETING OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

The Midyear Meeting of the Radiological Society of North America was held at the Copley Plaza Hotel in Boston, June 3 and 4, 1921. The reported attendance at this meeting was larger than that at any preceding similar meeting of this Society.

The scientific sessions, which were well attended, were presided over by Dr. Alden Williams, President of the Society.

The address of Dr. Coolidge on High Voltage Problems, and the paper of Dr. A. F. Tyler on Recent Developments in Deep Therapy Technique—Facts and Fancies, were especially timely.

Dr. Coolidge detailed some of the results obtained by working with two high voltage machines secured from Germany. He stated his belief that the voltages used for treatment in Germany at the present time are not so different from those obtainable from the x-ray machines in common use in the United States as we have been led to believe.

He explains the discrepancy by the different methods in use in the two countries of computing the voltage. He gave as his belief that there is as yet no reliable information on the effects of x-rays produced by voltages higher than those represented by a ten-inch spark-gap measured between spheres.

A practical conclusion to be drawn from the papers of Drs. Coolidge and Tyler is that the production of x-rays by higher voltages than those in common use in this country is still uncertain, and the results of treatment by x-rays produced by such high voltage currents are therefore still unknown. It follows that the time has not yet arrived when we should replace the x-ray machines now in use by others supposed to produce currents of higher voltage.

The entire program was well-balanced and well repaid the attendance of all who were there.

A. C. C.

CORRESPONDENCE

DR. H. M. IMBODEN, *Editor*
AMERICAN JOURNAL OF ROENTGENOLOGY,
480 Park Ave., New York City.

Dear Sir: In reply to the criticism by J.S. Shearer, published in the March issue of THE AMERICAN JOURNAL OF ROENTGENOLOGY, we wish to state that our formulae and methods of determination of x-ray dosage are based on Holzknecht radiometer readings and clinical manifestations of the human skin, also on nearly four years of actual operation in both clinics and private practice with standard apparatus.

Our modification of the radiographic formula $\frac{MA \times V \times T}{D \times D}$ was determined by a series of readings in which we found that

doubling the spark-gap without changing the other factors gave double the dose as indicated by the radiometer scale.

This was clinically verified by exposing different areas of patients' backs instead of the pastille. Those areas in which double the spark-gap of the erythema dose was used and the time of exposure reduced one half, showed the same degree of erythema and clinical manifestations. We therefore adopted the following formula for unfiltered therapy: $\frac{MA \times SpGp \times T}{D \times D}$

We also found that when a filter of aluminum was interposed, it only required twice the time to produce the same Holzknecht reading at full distance as that of half distance.

In order to establish biological proof by doing away with the pastille and substituting the human skin the following experiment was made:

A patient's wrists were exposed with three millimeters of aluminum as a filter, one wrist at a distance of 6 inches from the target and the other at a distance of 12 inches, both wrists being exposed at the same time. The wrist at 6 inches distance was withdrawn after seven minutes and forty-two seconds exposure. The other which was twelve inches from the target received fifteen minutes and twenty-four seconds exposure, i.e., double the time given the wrist at half the distance. Ten days after this exposure the erythema produced on both wrists was identical.

If the exposure at full distance (12 inches) had been made in accordance with the law of "varies inversely as the square of the distance," as in unfiltered therapy, the time of exposure would have been thirty minutes and forty-eight seconds or four times that of half distance.

If an exposure of fifteen minutes and twenty-four seconds at 12 inches produces an erythema, double that time (thirty minutes and forty-eight seconds) will produce an *x*-ray burn; therefore clinically instead of having both areas identical as a basis for determining dosage, one wrist would receive an *x*-ray burn and the other a simple ereythema.

It therefore follows that determinations of filtered *x*-ray dosage based on the same law of distance as in unfiltered dosage would involve disregarding entirely the clinical manifestations of the skin and would ultimately lead to permanent disfigurement, telangiectasis, keratosis and epitheliomatous degeneration of the exposed skin.

Unless some method is devised whereby the law of light and distance and the clinical manifestations of the human skin in filtered *x*-ray therapy coincide, we can see no reason why a law of physics should form the sole basis in determining dosage.

John Remer
William D. Witherbee.

BOOK REVIEWS

General Practice and X-Rays. A Handbook for the General Practitioner and Student, by Alice Vance Knox, M.B., B.Ch., with chapters on the production of X-Rays and Instrumentation by Robert Knox, M.D., C.M., M.R.C.S., L.R.C.P., containing 214 pages, 32 full page plates and 56 diagrams in the text. Price $5.00. A. & C. Black, Ltd., 4, 5, and 6 Soho Square, London, W. 1, 1921.

This is a very practical book and should prove very useful to that large class of general practitioners who have not had an opportunity to familiarize themselves with the rapidly developing science of radiography and radiotherapy.

The authors refer to the fact that a general practitioner does not find it easy to keep pace with the new developments in *x*-ray diagnosis and technique, and to appreciate to the full either the help that they can afford him or their limitations. This is especially true of the older practitioners who have been well established in their practice during the early days of the *x*-rays or even before Roentgen's discovery. The authors intend the volume as a practical demonstration of the value of *x*-rays in general practice, without attempting to convey a working knowledge of the *x*-rays.

Reference is made to the position of the radiologist in the field of medicine. He is idealized as a medically trained individual of experience in clinical diagnosis and pathology of that particular field in which he specializes in radiology. His opinion should be of value not only in the interpretation of plates and screen findings, but in the clinical diagnosis and in the prognosis. In other words, the position of the radiological expert is essentially that of a consultant. It therefore follows that the radiologist should be made fully acquainted with the history of the case and the existing physical findings.

The work is readable, clear, attractive from the standpoint of bookmaking, and should be of great assistance in popularizing and extending the usefulness of *x*-ray examinations.

James T. Case.

TRANSLATIONS & ABSTRACTS

PONTANO, T. Contributa alla Conoscenza Clinica e Radiologica della Sifilide Polmonare. (*Policlin.*, 1920, xxvii, 46, 1299.)

The diagnosis of pulmonary syphilis has in the past presented grave difficulties and "phthisis a lues venerea" represented the confused ideas prevalent. Much progress has been made, but even at the present day the clinical syndrome is not clearly defined. It has been demonstrated that syphilis may produce pulmonary lesions of a neoproductive type (gumma), an infiltrative type (broncho-pneumonia), a destructive type (cavities), and a sclerotic type.

Diagnosis at the present time is based on (*a*) recognition of a syphilitic soil, (*b*) contemporary syphilitic manifestations, (*c*) localizations in the lungs and radiographic findings, (*d*) exclusion of other processes, and (*e*) specific therapy.

In pulmonary syphilis roentgenology has not given as much as it might. The roentgenologic character as given in the literature may be summed up as follows: The process has a predilection for the blood vessels, spreads along the vascular ramifications, tends to invade the parenchyma from the hilus outward so that the shadow decreases in density toward the periphery. All radiologists observe that it may be difficult to differentiate between syphilis and tuberculosis.

Pontana reports the case of a man, aged twenty-two, whose clinical history and symptoms are presented in detail. The first roentgenogram taken March 13 showed, on the right side in the region of the second and third ribs and their interspaces, a more or less intense and rounded shadow continuous with the cardiovascular shadow and extending laterally to a point between the midclavicular line and the anterior border of the axilla. While intense, the shadow zones were of varying density and the shadow was not uniform. Its contour was somewhat irregular and its margin gradually blended with its surroundings. Branches extended outward like spokes from the shadow, some of the more prominent ones radiating toward the apex and the base. The roentgenographic picture aided in excluding echinococcus cyst and pulmonary abscess.

After syphilitic treatment another roentgenogram was made, April 2, giving a very different picture. Instead of the former intense shadow there was a trabeculation through which the pulmonary parenchyma could be seen. A portion of the lung had acquired its normal transparency, although there was still a less clear zone near the hilus.

Pontano believes that the roentgenologic examination "permits us to identify exactly the process. The irregularly rounded form with winding margins and the intense shadow with dark and light areas produce exactly the appearance of conglomerate gumma which are observed postmortem." In his conclusions he says that the roentgenologic study is "useful and carries great weight in the differential diagnosis even though insufficient to solve the problem by itself."

A. S. GIORDANO.
R. D. CARMAN.

ANTOINE, E. (Paris.) General and Radiologic Study of Simple Duodenal Ulcer. (*Gaz. d. hôp.*, March 19, 1921, xciv, 23.)

Radiography should always be practiced on the mere suspicion of duodenal ulcer. To corroborate the clinical diagnosis a roentgen examination is of the utmost importance. The art of diagnosis by the rays is a recent acquisition but has been gradually improved. The duodenum and stomach should be studied independently of each other. In the duodenal direct examination a deformity of the duodenum is usually seen, but normal findings do not exclude the presence of ulcer. Much difference of opinion has arisen over the exact significance of this apparent deformity and of the rôle played by local spasm, the latter perhaps modifying the actual deformity. Operation with the diagnosis of marked deformity may reveal only a slight deformity. The author enumerates varieties of deformity as laid down by Carman. The maximum visibility is at the level of the bulb of the duodenum and the deformity is not always easy of interpretation. Naturally any diagnosis based on the presence of deformity requires repeated examinations,

for constancy is the leading element in the diagnosis. If due to spasm a second examination may prove negative in this respect. The indirect or gastric examination is not less important and the diagnosis may be made by it alone. The positive evidences are hyperperistalsis, hypertonus and rapid evacuation. The hypertonic stomach is small, high placed and with parallel walls; hyperperistalsis is visible under the screen, is an intermittent phenomenon as well as inconstant. Rapid evacuation is also brought about by radioscopy, as shown by Barclay. Radiographic diagnosis also includes numerous evidences of duodenal stenosis resulting from ulcer.

Du Pont, J. Slight Fractures of the Base of the Acetabulum. (*Presse méd.*, February 16, 1921, xxix, 14.)

In a recent number of this journal Basset called attention to the possibility that slight fracture of the acetabulum is more common than has heretofore been believed and that this lesion could be confused with contusion of the hip. Slight fracture in this locality with deepening of the acetabulum is an accident which was unknown before radiography. Broca once treated a case in a woman who fell on her great trochanter and presented symptoms which suggested a plastic arthritis. It was five months before the joint became normal. The leading symptom was pain upon pressing upon the great trochanter. Recently a patient was admitted to Broca's service who had been kicked on the great trochanter by a mule. The symptomology was meager—hardly more than a bruise *in situ* and slight local pain. Digital exploration of the rectum disclosed a sensitive area on the horizontal ramus of the os pubis. Earle regards this symptom as evidence of facture of the base of the acetabulum. The x-ray showed the correctness of Earle's sign. The head of the femur was in the cavity but the latter was seen to be deepened from fracture through its base. Two spiculae of bone were seen to project into the pelvic cavity. Kantowitsch has called attention to the projection of a single speculae into the pelvis, either superiorly or inferiorly placed, but here, as stated, there were two of these fragments. A slight joint reaction followed the injury and required the use of extension for eight days. The final outcome of the case is unknown. These so-called benign fractures must not be confused with the severe type in which the acetabulum is comminuted and the head of the femur forced into the pelvic cavity. Such accidents were well known in the pre-radiographic period and there is a large literature upon the subject.

Antoine, E. (Paris). A Case of "Appendicular Sciatica." (*Gaz. d. hôp.*, March 1-3, 1921, xciv, 18.)

In 1913, Enriquez and Gutmann described what they termed "limping appendicitis." The author has noticed a close relationship between this affection and the one termed "appendicular sciatica." A patient was seen by him recently with what apparently was sciatica, treated in vain for several months. There was an abortive abdominal symptomatology which did not interfere with the diagnosis. The use of the x-rays and a blood count made a diagnosis of chronic appendicitis. The pain was first noted in the heel and was felt higher and higher until it was referred to the right thigh. The pains could not be made to subside and became so severe at last that the patient could neither walk nor work. He then entered the hospital for treatment. The hospital diagnosis was right-sided sciatic neuralgia and the treatment consisted of rest, aspirin, sedative frictions and epidural injection of novocainized serum—all without benefit. The pains always came back as soon as he stepped out on the floor. The hospital physician began to suspect imposture.

When the case came under the author's hands he was surprised to find no tender pressure points, while extension of the lower extremity was but slightly painful. Only abduction of the thigh caused marked pain. Examination of the abdomen left no doubt that whatever else was present the man had chronic appendicitis. Radioscopic examination showed stomach normal, cecum high up and not voluminous, not descending to its normal recess. The margin of the shadow showed deep notches and the base of the cecum was immovable and fixed to the posterior portion of the pelvis in both standing and recumbent postures. The diagnosis was confirmed by the result of operation. In regard to the radiologic diagnosis the fixation of the cecum in the right iliac fossa, irrespective of position, checked up by a tender point at the internal

border of the cecum opposite the appendicular insertion, was sufficient for the diagnosis. An acute exacerbation of an old lesion had set up the syndrome of sciatica.

SCHLECHT, H. (Kiel.) Relative Values of Occult Blood and Radiography in the Diagnosis of Cancer of the Stomach. (*Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1917, xxix, 469.)

For early diagnosis of cancer of the stomach the author rates the x-ray as superior to most of our diagnostic resources, although temporarily inferior to the demonstration of occult blood in the stools. The roentgen investigation cannot be standardized and may not be available at all. It is further a question whether radiography can determine the stage of development of the cancer. If the two resources are taken jointly with both tests positive we can be certain of our diagnosis in the absence of all other data: and even if the radiogram is only suspicious of cancer, the presence of occult blood will have a notable diagnostic significance. The author cites an unusual case for diagnosis in which there were present a high degree of cachexia, metastases in the liver and occult blood in the stools. The question to be answered was, "Is the primary growth in the stomach or elsewhere?" On both the screen and plate could be seen an anomalous condition of the lesser curvature, the interpretation of which was very difficult. It could have been a carcinoma or merely a perigastric adhesion. As the evidence continued to be inconclusive, a high bismuth enema was taken and a radiogram of the colon taken. The primary growth was seen in the sigmoid and the diagnosis confirmed by autopsy.

LIVIERATO, P.E. (Genoa), The Abdomino-Cardiac Reflex (Sign of Livierato) as a Means for Determining the Tonicity of the Myocardium. (*Grèce Méd.*, December, 1920, xxii, 12.)

Professor Livierato isolates a type of dispensary patient who presents on physical examination no evidence of myocardial insufficiency, but who complains of precordial oppression, with or without dyspnea, especially after a meal. This symptom disappears on moderate exercise. The author made the discovery that this type of patient when repeatedly struck over the epigastrium in the middle line and in the antero-posterior direction showed an increase of cardiac dullness along the right margin. This was especially noticeable in the upper portion, the area of dullness passing upward several centimeters. The outer (left) border remained unchanged. This phenomenon was confirmed by the x-ray, both by radioscopy and radiography. It was also shown that after light gymnastic exercise the condition subsided. The author explains the phenomenon as follows: the blows struck abruptly on the abdominal wall provoke a reflex which apparently causes a dilatation of the cardiac chambers, especially of the right ventricle. This fact should imply that somewhere in the circulation an obstruction is present. The possibilities of this kind are so numerous that it is not worth while to state them in detail. It has been shown by Degiovanni by cardiography that ingestion of food, even in the healthy, increases the intrapulmonary tension. As a result of animal experiment the author infers that the blows on the epigastrium cause vasoconstriction of the pulmonary vessels. When this dilatation occurs spontaneously, it is doubtless instigated in subjects with hypotonia of the myocardium, by the mere fact of the ingestion of a meal.

HAMPELN. (Riga.) Symptomatology and Diagnosis of Primary Malignant Growths of the Lung. (*Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1919, xxxi, No. 5.)

Some of the author's material evidently antedates the x-ray period and he claims that their resource is of no additional diagnostic advantage in the advanced stages, although valuable in the initial period. He enumerates thirteen cases of primary malignancy of the lung and other local affections in which the diagnosis was mistaken, thus giving an idea of the chance of error in both directions. It should however be stated that malignancy of the lung is often complicated with gangrene, bronchiectasis, pleurisy (empyema), fibrosis, etc. There is frequently confusion with tuberculous lesions. In these mistaken diagnoses it does not appear that the x-ray figured with a single exception. Here the diagnosis of "cancer" was made clinically. The x-ray diagnosis was limited to "neoplasm of the lower lobe." An autopsy could not be obtained.

A case cited by the author is of interest. The patient was an unusually vigorous man of fifty-six in perfect health save for a recent series of hemoptyses. There was dullness of percussion over the manubrium region and the suspicion was of malignant disease. The radiogram showed a shadow given off from the highest point of the vascular shadow with which it was homogeneous. No pulsation was observed on the screen or clinically. This shadow resembled one of aneurysm published by Romburg and another of the same origin by Baetjer. The hemorrhage might therefore have been due to erosion of the aneurysm into a bronchus. Four plates were made over an interval of two months. The shadow broadened with time and toward the right side. Finally the secondary shadow could be seen to be distinct from the cardiovascular shadow, and the diagnosis was changed from aneurysm to neoplasm. The patient survived three months and autopsy revealed a round cell sarcoma of the upper lobe with extension into the right main bronchus.

Paisseau and Solomon. Radiologic Aspects of Influenza Pneumonia and Bronchopneumonia. (*Bull. et mém. Soc. méd. d. hôp. de Par.* February 17, 1921.)

The pulmonary complications of influenza have assumed different forms, so that while in one case we see a hemorrhagic bronchopneumonia, in another the lesions are of the frank lobar pneumonic type and less severe. In still other cases there is a pseudo-bulbar pneumonia associated with a diffuse bronchitis and scattered foci of bronchopneumonia. Radiography is an excellent resource for differentiating these three pneumonic types. In frankly lobar pneumonia the shadow shows that the mischief is limited to a single lobe, the borders of which are sharply outlined, and when occurring in influenza the location is for the most part unilateral with a tendency to involve the left side; while a special characteristic is the emergence of the process at the hilus region. American authors have insisted on the latter as a constant feature as a result of early examinations of influenza patients. In typical bronchopneumonia the shadow is characterized by irregular contours the margins of which are less precise and diffuse than in the pseudolobar form. The involvement of the lobules suggests the shadow of a tuberculous lung. The bronchopneumonic form begins at the hilus as in the frankly lobar form with accentuated density and the shadow of peribronchial thickening. By extension there appear small, rounded shadows of diffuse contours, more or less confluent, with a tessellated appearance suggestive of tuberculosis. In certain cases both types of shadow, lobar and bronchopneumonic, may coexist and in these cases the radiologic diagnosis of pseudolobar pneumonia is evident. Characteristic of all of the types is initial invasion of the hilus region.

Knox, Robert. Treatment by *X*-Rays and Radium. (*Brit. M. J.* February 26, 1921, No. 3139, p. 3004.)

X-rays are the best treatment for tinea capitis. In rodent ulcer radium is better than *x*-rays, as there is less frequent relapse after using radium. When it relapses there is resistance to second healing. Lupus vulgaris sometimes gives good results. Too much treatment of it exposes to the danger of lupus carcinoma. Hyperhidrosis is readily controlled by *x*-rays. In leukemia the immediate effect is striking and the control may go on for years, but the final result is nearly always relapse. Radium is better than *x*-rays, as also in Banti's disease. In exophthalmic goiter radium should be used. Simple inflammation of lymphatic glands and lymphadenoma quickly respond, so also with sarcoma, but with the latter relapse occurs. With tubercle and carcinoma the response is slow. In fibromyoma of the uterus reduction occurs to half or a third, but tumors never disappear. Great improvement however occurs in health from cessation of the hemorrhage. Some cases do not respond. In carcinoma of the breast he advised *x*-ray treatment before and after the operation. Some inoperable cases become operable after *x*-rays.

A. H. P.

Morton, Reginald. *X*-Ray Radiation and Cancer. (*Brit. M. J.* No. 3135, Jan. 29, 1921, p. 172.)

The author believes that radiation is more likely to provide cure for cancer than anything else. He advocates exact dosage with a 16 inch spark gap and a filter of 12 milli-

meters of aluminum. The Coolidge tube is unsuitable for the treatment. At Erlangen the tube is standardized by biological methods and recalibrated at intervals. A thirty-five minute treatment is followed by redness in a week. No ulcer follows, and tanning occurs after three weeks. This is the unit dose. Taking this as 100, a cancer cell requires 110 to destroy it, 70 to 90 will paralyse it so to speak, and it may recover. A dose of 40 stimulates it to increased growth. Six ports of entry are used for the uterus. This is not possible for breast cases which are treated at a long distance. The treatment may last from five to ten hours. In the Erlangen results dating back from 1918, 20 of 24 cases of uterine cancer were quite well. Since 1917, 75 per cent of the mammary cases are clinically cured.

A. H. P.

A reply to the above (which is heresy) is the following:

JOHNSON, F. HARNAMAN. The immunizing effects of X-Rays in Carcinoma. (*Brit. M. J.*, March 5, 1921, No. 3140, p. 365.)

The author replies to Dr. Morton's claims for the Erlanger method of treating cancer by *x*-rays. Neither quantity nor quality of *x*-rays in themselves guarantees success. X-rays act by local and general stimulation of the protective mechanisms of the body. It would be dangerous to operate after the Erlangen massive doses. The author advocates instead eight small doses distributed over three weeks. He believes that the *x*-rays act like vaccines, raising the resistance of the patient to cancer invasion. The results of the Erlangen treatment are not convincing. The immunizing effects of *x*-rays are seen in tubercle and Graves disease and he infers from his experience that there is an immunizing effect of *x*-rays in cancer.

A. H. P.

STRÖM, S. (Stockholm.) Roentgen Differential Diagnosis between Osteitis Fibrosa, Solitary Bone-Cyst and Tumor. (*Acta Chirurgica Scandinavica*, December 11, 1920, liii, 2.)

This subject is of great importance, and while the radiologist is presumably familiar with the appearances of the three affections, the latter sometimes shade into one another, and make the problem of differential diagnosis less simple than one would think. In the first case cited by the author the diagnosis of osteitis fibrosa was made only with great difficulty. The lesion was situated in the upper extremity of the humerus and was characterized by extensive deformity of that portion of the bone. In order to exclude the possibility of local neoplastic formation it was necessary to show that the osteitis involves the greater part of the humerus. The author was able to demonstrate from the plate that the structure of the balance of the bone was quite abnormal, even though the gross appearance showed no change. The opposite humerus was studied for control. The deformity, which gave to the bone a club shape, extended downward into the diaphysis and the usual bone structure was obliterated with the suggestion of a cavity formation. The cortical portion in the deformed area was considerably thinned and pressed outward. Upon studying the remainder of the shaft the same thinning of the cortex was evident in places with increase of the marrow cavity, although the diameter of this shaft agreed with that of its fellow on the opposite side. Three years before, there had been a fracture through the upper part of the humerus following a slight violence, and the fracture line was evident in the plate. The decisive feature in osteitis fibrosis is not the structure of the bone but the involvement of the greater portion of the gross non-deformed part of the bone in the morbid process.

HELM. The Tabetic Stomach under X-Rays. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, iii, 25.)

Proof is given in twelve cases that in individual cases at different times completely different appearances may be presented. A connection between the subjective and objective findings with reference to the stomach-picture cannot always be determined. Also in cases subjectively similar, sometimes one sometimes another picture is to be found. In the majority of cases marked subjective symptoms are associated with a radiograph deviating from the normal; above everything, spastic conditions of the stomach are not to be confounded with true hour-glass forms. Very noticeable are the considerable variations in tonus yielded by the

stomachs of individual tabetic patients, where marked atony may alternate with normal tonic behavior. The atonic stomach indicates a pause in the attack.

SIMON. Adhesions in the Cecal Tract Diagnosed by X-Rays. (*Hygiea*, Stockholm, lxxx, 241.)

Two cases of strangulation of the lower end of the ileum due to adhesions following an operation for appendicitis which was performed several years previously. For comparison the author refers to 23 earlier published cases of stenosis of the ileum, in 16 of which there was a history of carcinoma or tuberculosis. Whilst the radiograph showed stenosis distinctly in the latter cases, in the two first mentioned there was no real stenosis, but only a slightly retarded filling of the cecum, together with slight dilatation of the lower coils of the ileum and a noticeable distention with gas. These differences, which can be recognized by means of the rays, make a differential diagnosis possible between neurotic nervous troubles after appendicitis and those due to the actual existence of adhesions.

BECERRO DE BENGOA. Radium Therapy of Cancer of the Uterus. (*Annales de la Faculté de Médecine*, ii, 886.)

Supporting his testimony on the treatment of 200 cancers of the uterus treated by radium, the author arrives at the following conclusions:

1. Radium possesses a truly specific action in regard to cancer cells.
2. Vegetative cancers yield more rapidly and are of less serious prognosis than infiltrating or corrosive tumors.
3. Radium often produces pseudo-cures due to an amelioration of the cancer of the cervix, making at the same time an advance in the body of the organ which manifests itself sooner or later.
4. These pseudo-cures are due to an inefficient technique. In fact, if the ideal situation of the radium tube is the cervical cavity, it is nevertheless true that this position can rarely be utilized. More frequently the tube is placed in the vagina, in more or less perfect contact with the external os. The author favors the employment of special thin silver tubes, having four projections on their exterior surface, which prevent them from falling into the vagina. They are placed in position after dilatation of the cervix, and it is then easy to deposit inside these tubes the radium tubes, kept in position by a compress. The cervix and the adjoining tissues are submitted to radiation. There is no danger of cervical occlusion, and all the radiation is absorbed by the neoplastic cells.

LUMIERE, A. The Precision of Radiographic Images. (*J. de Radiol. et d'électrol.*, iii, 97.)

Four rectangular sieves, made of wires of different diameters, were supported 10 cm. above a photographic plate, the anticathode of the x-ray tube being 50 cm. away from the plate, and photographs were taken under different conditions of working. It was found that the focal spot is slowly modified in the course of a long exposure, broadening to an appreciable extent. It also suffers a slight displacement when the tube is run for several minutes. In another group of experiments the current strength was varied from ¼ m. amp. to 15 m. amp., the exposure being correspondingly shortened, but the differences in definition were not appreciable. On the other hand, when the tube was softened so that the equivalent spark gap was reduced from 18 cm. to 3 cm., the definition was not so good. Trials with other tubes gave opposite results, and for every tube there appears to be a particular hardness for which the definition is a maximum. It is considered, however, that the variation is not of great importance. Every tube appears to be able to furnish an image, the definition of which depends on the tube, and is little modified by the conditions under which the tube is run. Four photographs taken with the anticathode 30, 50, 100, and 150 cm. from the plate, the exposures varying directly as the square of the distance, show the improvement in definition obtained by increasing this distance.

The experiments relate only to the definition properly so-called; they are not concerned with the degree of contrast obtainable with a tube. For example, a hard tube might give excellent images of all four sieves, but would not be so suitable for examining a case of renal calculus as a softer tube which did not show the finer

wires. As the lack of precision seems to result from the surface of impact on the anticathode not being punctiform, but of an appreciable area, two photographs were taken, one with the tube in the normal position and the other with the anticathode nearly perpendicular to the plate. In the latter case the projection of the focal spot on the plate is a thin line, and the images are greatly improved in one direction. It is concluded, therefore, that one of the essentials for the obtaining of a greater precision in radiographs is the reduction of the size of the focal spot.

Laborde, A. Apparatus Employed in Radiumtherapy. (*J. de radiol. et d'électrol.*, iii, 106.)

This is a general review of the properties of radium and its radiations. Reference is also made to the transformation products of radium. A feature of the paper is a table showing the percentages of soft B, hard B, soft Æ, and hard 1/4 radiation transmitted by various metals, bone, and some organic substances, when the thickness of the absorbing material varies from 0.1 mm. to 20 mm.

Arthur C Christie

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X-RAY EXAMINATION OF THE CHEST AND AN X-RAY CLASSIFICATION OF PULMONARY TUBERCULOSIS*

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THE object of this paper is to bring to the profession a practical method of x-ray examination of the chest, based upon 10,000 such examinations, each checked by careful physical examination and history or autopsy, and to present the x-ray classification of tuberculosis used at the Cincinnati Tuberculosis Sanitorium.

The primary purpose of the examination is to locate and describe abnormal densities and thus detect tuberculosis, identify its type, and differentiate it from other chest lesions. In this way I am able to classify tuberculosis, arrive at a more perfect diagnosis, and secure a workable basis for prognosis, and am enabled with certainty to outline the necessary treatment from the very beginning of my care of the case. This is made possible because stereoscopic chest plates are of prime importance in determining pulmonary pathology.

The limits of an x-ray chest examination must be frankly stated. X-ray studies of lungs and chests by many workers during the last twenty years have proven that a physical examination, even in expert hands, has great limitations. The limitations of each method have been proclaimed by men who were not fully familiar with the method they criticised, so that to-day the profession has only a hazy knowledge of what it may expect from each method.

The greatest value of any single sign of a physical examination of the chest is the detection, location, and classification of râles. This is so important that our late army experience has developed the erroneous theory that clinical tuberculosis should only be diagnosed by râles. The truth of the matter is that you may have râles upon inspiration, over a limited area, without tuberculosis, and that you may have active tuberculosis without râles.

In a case of incipient tuberculosis the râle is of great importance for the same reason that the x-ray fan is important, viz., that the common adult pulmonary lesion is cone shaped and its base comes to the pleura. Thus, when you have the adult type of tuberculosis you have inflammation with exudate at the point of inoculation, which partially fills the air cells and distal portion of the bronchial tree; the extent of the lesion is limited by the septa of the lung, which extends into the lung from the pleura in such a manner as to form a cone with its base at the pleura. The stethoscope easily detects such lesions because of their superficial location,

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and we hear a shower of fine râles breaking immediately under the ear. They are usually heard at the beginning of inspiration, and because they are generally not so acute as other forms of pneumonia the patient must often exhale and cough before they are brought out. It must be realized that this is not a pathognomonic sign of active pulmonary tuberculosis but is a sign of localized inflammatory exudate from which tuberculosis must be excluded. Early tuberculous adult lesions are most commonly found in the apex of a lobe—sometimes in the apex of a lower lobe. So the location of such findings must be carefully considered when making a diagnosis.

It is not generally realized that râles due to tuberculous lesions frequently disappear after a few weeks or months and that râles due to localized apical pneumonia, such as we had during the late epidemic, frequently persist for months. Further, it is not generally known that we have at times central spherical areas of tuberculosis which may give no such râles. Most important to remember is that we may have very extensive lesions of tuberculous caseous bronchopneumonia without physical signs. The purpose of these few remarks upon physical signs is not to discuss the physical signs of tuberculosis, but to show some of the values and limitations of the *x*-ray.

While râles due to pulmonary tuberculosis may come and go, this is not true of the abnormal densities in the lungs due to tuberculous lesions. They may change but they never go. Thus we have a record of the past, and although the râles have disappeared an old area of tuberculosis is easily detected by the *x*-ray. A fan due to a recent tuberculous invasion, in which the râles may be very characteristic and due to recent localized tuberculous exudate, is difficult to detect upon the *x*-ray plate. Thus, the usual error in reading *x*-ray plates of tuberculous cases is to overlook recent active lesions, or to diagnose non-tuberculous lesions of similar density as tuberculosis. The usual error of the clinician is to overlook old lesions and thus underestimate the extent of the pathology. Such densities must be differentiated from artefact, and from localized exudate due to other causes. Artefacts are corrected by proper roentgen technique.

I wish to call attention to the limits of a roentgen examination of the chest due to error of technique. Breathing during exposures or between stereoscopic exposures may obscure delicate pneumonic fans or may cause them to appear when they do not exist. If plates are repeatedly taken in the same position, it is easy to determine the normal position of the trunks and thus localize the lobes of the lungs. Many positions can be used, but for each position the normal anatomy must be worked out. I have carefully worked out the anatomy for one position, and if the lobes of the lung are to be determined by my method, that position must be maintained. I have witnessed some grave mistakes made in localizing a lesion, by failing to observe the positions of plate, tube and patient described in one method, yet trying to read these plates by that method. I have seen the same lack of correlation by having Dunham's fans pointed out to me in pictures of perfectly healthy men who have breathed between stereoscopic exposures in three-second exposures.

Hard tubes with rapid exposures do not obscure the delicate fans, but a tube with a five inch spark-gap or less exposed for three or four seconds will cut out very delicate fans.

Errors of interpretation are the most difficult to overcome. Nothing can overcome this, but a knowledge of the normal lung anatomy and the normal lung densities will greatly reduce the errors. (Miller[1] and Dunham.[2])

At this point I wish to state that a delicate fan limited to one apex of an adult should be noted and described, but should not be diagnosed as pulmonary tuberculosis, because it is probably due to other etiological factors. Let us look at the reason. The lesion, if in the lung, is due to exudate. It might be a pleural lesion mistaken for a fan. If due to tuberculosis it is our first exudative lesion, and it is very unusual to find a first exudate. Such patients are not sick and seldom consult a physician, while patients with localized pneumonia due to acute infections are usually

sick or have troublesome symptoms. Thus you can differentiate between tuberculous and apical râles which persist after la grippe and influenza. If possible, it is important to determine whether such densities are actually within the lung or in the pleura. If such a lesion is active it can easily be determined by the stethoscope. Therefore, the clinician's attention should be called to the density and its character described. Such lesions when due to tuberculosis are easily arrested and the patient should not be branded as tuberculous. Such densities often exist for life after an attack of pneumonia or empyema, or a healed tuberculous lesion, and it is often impossible to decide the clinical significance of such densities from the plates alone. Age should always be considered—they are of less significance after thirty. Thus we have definite limitations of the x-ray which should be acknowledged and left to the decision of the clinician.

When both apices are involved we have a better chance, because if one is due to tuberculosis the pulmonary lesions are of different ages and one density will differ from the other. Thus it is usually easy to say definitely whether one or more of these lesions are within the lung tissue. But still we are dealing with slight lesions and must be guarded. The clinician should give greater weight to such findings, but we must be guarded in our reports and frankly acknowledge another limitation. Activity in such a case is very difficult to determine from the plates.

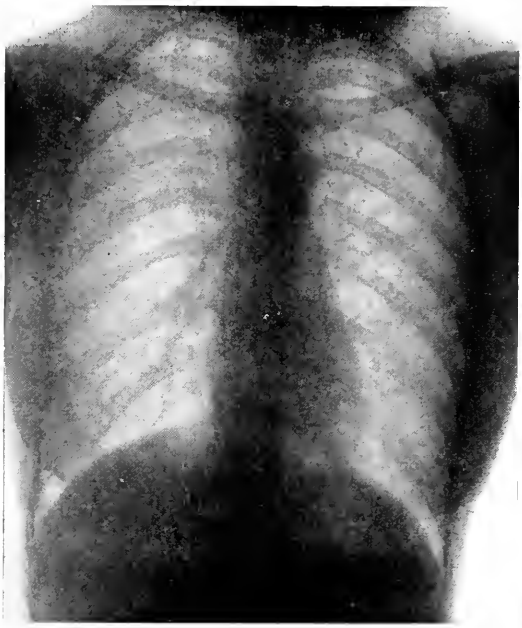

Fig. 1. No. 1986.—Plates taken by Coolidge tube medium focus with more than 9 inch spark, 50 ma., 39 inches distance, a half second exposure on a seed plate without screen, of a light-framed woman weighing 119 pounds. Plate is normal except for some ptosis. The value of this technique is that it holds the lung markings equally well at apex and base.

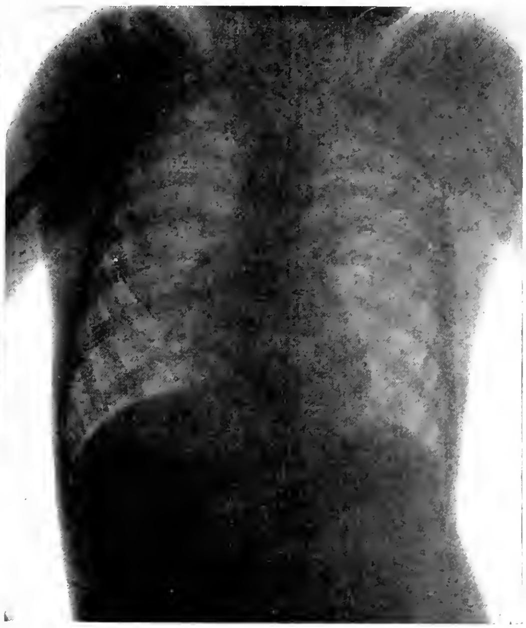

Fig. 2. No. 1865.—Child, age eight. Case showing few calcified nodes at the hilum which probably indicate tuberculous infection. There is no lesion in the lung. This child has a tuberculous history, but has no physical signs or symptoms. Heart enlarged to R. which is unusual.

The most excusable error is when we find one or more old tuberculous fans and a recent active fan below this. Such a lesion should always be diagnosed as recently active tuberculosis; yet I have had two such cases which were due to influenza engrafted upon an old tuberculous lesion. Such an error is on the safe side, because unless this patient is treated as tuberculous there is every likelihood that the old lesion will be reactivated by the acute process. This is another limitation.

Pneumonoconiosis, acute bronchopneumonia and malignancy will be considered later.

In an article entitled "X-Ray Chest Manual" I covered the technique and reading of x-ray plates. Since this was written I have developed a Coolidge tube technique which I wish to report, and I wish further to add a statement as to the value of the fluoroscope. The fluoroscope can in no way compare with the stereoscopic chest plates in detecting slight lesions, such as minimal tuberculous lesions, nor in studying the various pathology of gross tuberculous lesions. Its value lies in studying motion. Thus the movement of the diaphragm, the pulsation of the heart and the aorta, posterior mediastinal space, and the passing of the barium bolus through the esophagus can be best studied by the fluoroscope.

A medium focused universal Coolidge tube, 39 inches from the plate, excited by 40 ma. to 60 ma. (with a 9 inch back up between points, under full load), exposed for a half second, will take a good chest picture of a 150 pound man upon seed plates. It is necessary to develop these longer than the usual exposure, sometimes as much as fifteen minutes. To do this it is necessary that the chemicals be clean and the temperature 65° to 68°. (Fig. 1.)

If plates are taken at 39 inches they can be used with proper modifications to determine the size of the heart. Such technique will bring out the lung markings so clearly that the bronchus of the lung tree can be studied readily from good stereoscopic plates.

Before reading and interpreting lung plates it is necessary to understand the normal plate, or rather, the average plate of normal individuals at various ages. Almost every scar and calcified area within the lung leaves a mark upon the plate, and as all adults have such areas they must be recognized for their true value. Thus the marks of tuberculosis are almost universally observed in adults who have grown up in congested communities. They have been infected with tuberculosis but they do not suffer from tuberculosis. "They have the infection but not the disease." It is obvious that a diagnostic procedure which detects and does not differentiate such infection and disease has little value. Lesions due to infections which have healed are probably our best protection against pulmonary tuberculosis. Calcification at the roots of the lung of an adult chest, in which no fans can be demonstrated at the periphery, should be considered as resistance and not disease. This truth was suggested early in my investigations, when the first fifty sets of stereoscopic chest plates of healthy adults showed much greater calcification within the hilum and much more thickening and studding of the trunks than did fifty cases suffering with active pulmonary tuberculosis with which they were compared.

Therefore, it was evident from the very first that the roentgen examination to be of value must differentiate between infections which had healed and which were a protection and those which were active, had clinical significance or limited lung function, and were a danger to the patient. Here I wish to make the general statement that when we have definite fans of increased density within the lung, we are dealing with a lesion which causes loss of lung function, whether we have an active process due to tuberculosis or pneumonia of other etiological factors, or an inactive lesion such as pneumonoconiosis.

It is the characteristic densities of a fan that are pathognomonic of tuberculosis and not the fan itself. The fan is characteristic of a pulmonary lesion and results from the anatomy of and physiology within the lung, but the characteristic tuberculous density results from the pathology of tuberculosis and the tubercle is far from being the only pathology. The tubercle alone, even the conglomerate tubercle or individual areas of caseous bronchopneumonia as seen upon the plate, are not characteristic of tuberculosis.

If we exclude acute pneumonic infections of the lung, pulmonary tuberculosis is the most common lesion we find. Its clinical and pathological manifestations are so varied that tuberculosis must be eliminated before any other diagnosis can be substantiated.

Therefore, if in reading chest plates we start with a knowledge of the chest plates in healthy individuals and a knowledge of the

chest plates of the various forms of tuberculosis, we have gone far in mastering this difficult subject. No roentgenologist would expect to read bone plates without a careful study of the anatomy of the part studied. This preliminary necessity is even more true in the interpretation of chest plates. The physiology of the lung, especially the lymph flow as well as the pathogenesis of tuberculosis, must be undestood. Where pulmonary tuberculous lesions start—how they spread and how the lesions in the child differ from those in the adult and how each is recorded upon the roentgen plate—will be dealt with under Classification. Here I wish to impress the fundamental truth that without these preliminary necessities it is hopeless to interpret chest plates and to deduce from them the all-important prognosis.

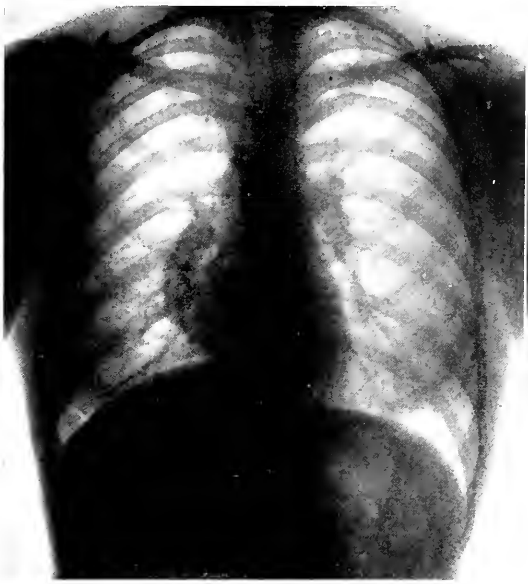

Fig. 3. No. 1770.—Child, age fourteen. Extensive calcification of nodes at the hilum with no parenchymal lesion.

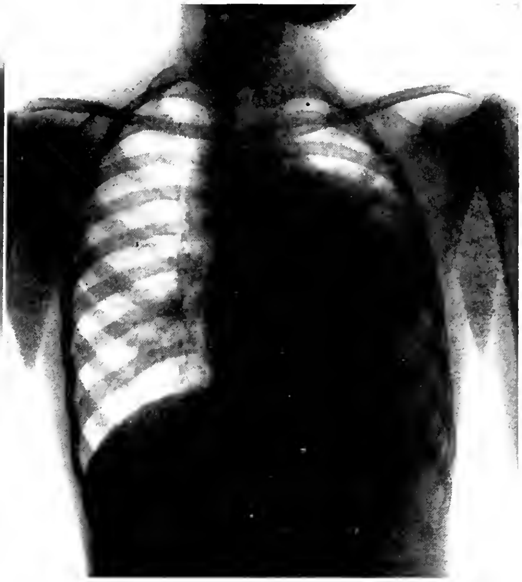

Fig. 4. No. 1912.—Puerile type of tuberculosis in child. Massive tuberculous pneumonia with large caseous nodes at hilum. No apical lesion. Findings verified at autopsy. Child colored, age fifteen.

Pulmonary tuberculosis is not always present when tubercle bacilli are reported in the sputum. For fully ten years I have realized the truth of this statement, but have not had sufficient proofs to allow it to appear in print under my name. To-day I fearlessly state the truth. The proofs are beyond question, but I hasten to add that such cases are rare, and such a diagnosis can only be made after great care. I have had 8 cases in this series of our 10,000; 2 proved to be acid-fast bacilli other than tubercle bacilli, and 6 were due to old nodes rupturing into a bronchus, from which large numbers of bacilli were expelled for a few days and then were found no more. No evidence of lung involvement was ever found.

Fig. 5. No. 1736.—Puerile type of tuberculosis found in an adult. Massive tuberculous pneumonia, left side, without apical lesion. Negro, age nineteen.

I cannot say that these 8 cases are the only ones which have occurred, but they are the only ones which I have proven.

Many more cases of lung stones have occurred, some have been without tubercle bacilli in the sputum and some have had definite pulmonary lesions. These 6 had no pulmonary lesions by physical examination, by *x*-ray examination, or by subsequent history. It is stated over and over again that the presence of tubercle bacilli in the sputum is the one infallible sign of pulmonary tuberculosis, and it is this broad statement which I wish to challenge by stating that it is not infallible, but that it is the one which is most nearly infallible. Most errors arise by improper technique in preparing and interpreting slides, some from other acid-fast organisms, and an important group are those nodal infections in which the pulmonary lesions have healed but which later rupture into a bronchus. If the small cavity quickly drains, the lesion is soon healed, to the great surprise and chagrin of the physician. It is possible to conceive that the patient may be reinfected by such a discharge or that a calcified stone, which for some reason of size or position has not been expelled, may keep up cough by irritation. In these 6 cases reinfection did not take place, and an irritating cough did not follow, and 5 of them did expectorate lung stones. I would not have had these histories of lung stones had I not impressed upon the patients the necessity of watching for them.

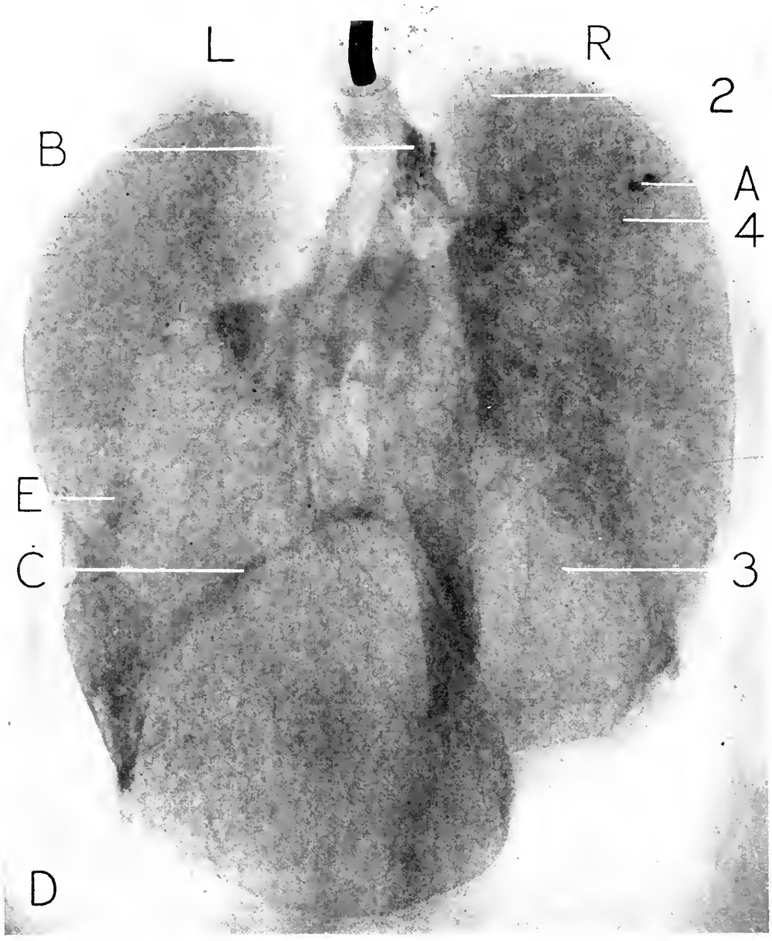

FIG. 6. No. 1256.—E. S. Active miliary tuberculosis. (Such a case has rarely come for autopsy.)

These cases were found by making routine

stereoscopic chest examinations and especially by studying all cases with a clinical diagnosis of tuberculosis which did not show positive evidence of pulmonary tuberculosis upon the plates.

In the same manner many cases of bronchiectasis are found as well as a few abnormal densities in the lungs which promptly clear up with antisyphilitic treatment.

Generally an *x*-ray diagnosis of pulmonary tuberculosis should be limited to parenchymal tuberculosis in the adult. It is unwise to read peribronchial tuberculosis and hilum tuberculosis from an *x*-ray plate. The reason for this is simple. As stated above, we can seldom determine whether such densities result from healed lesions (infection) or active lesions (disease). They may be roughly considered active in a child and healed in an adult. They can never be considered tuberculous without calcification. Heavy trunks and hilum shadows result from many pulmonary infections, and as all adults have suffered from pulmonary infections by the tubercle bacillus or some other organism it is manifest that all adults will show peribronchial thickening and heavy hilum densities. I know of no way to separate these groups by the *x*-ray plate, and I have lungs which have been *x*-rayed to determine this point (Fig. 11). It is true that heavy trunks in the upper lobes are often associated with tuberculosis, but it is also true that if stereoscopic plates are carefully taken and carefully read, small fans will be found involving the linear markings beyond these trunks.

Pathologically peribronchial and hilum tuberculosis exist, but we have no way of deciding when they have clinical significance or when the densities are caused by infection other than tuberculosis.

I have not found the use of such distinctions necessary to check plate readings with clinical and pathological studies and conclude that when unaccompanied with fans peribronchial thickening in the adult has little clinical significance, and should not be described in the report. Its greatest use, as I have seen it, has been to furnish a loophole for the roentgenologist. Thickened trunks and heavy hilum densities may be valuable in reading the plates of children, but only as a study, not as a final diagnosis.

Heavy trunks and heavy hilum shadows containing definite caseous or calcareous areas in children's plates, according to my present knowledge, may be considered tuberculous, but I am unwilling to go farther unless they show definite fans and can be classed as adult tuberculosis.

There is a peculiar calcified area seen in the hilum which has clinical significance. This I have termed a caseocalcareous node.

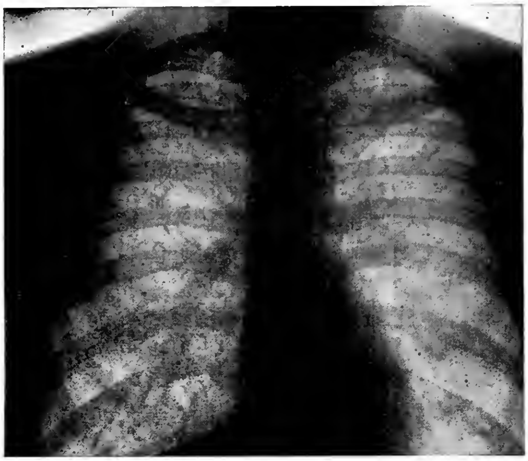

Fig. 7. No. 302.—Healed miliary tuberculosis.

Upon the plate it has the density of calcium. It is usually quite large and can be seen to be made up of many small flakes of calcium rather than one stone. Upon section we find a soft caseous center containing microscopic calcium and large, hard flakes of calcium around the periphery. Such lesions I have never found to be healed and they should always be considered as potential foci of infection.

AN X-RAY CLASSIFICATION OF PULMONARY TUBERCULOSIS

The lung with its pathology is regarded as a whole adaptable to classification, especially to *x*-ray work.

1. *Adult Tuberculosis:*
   Syn. Secondary tuberculosis,
   Nodose tuberculosis,

Apical tuberculosis,
Chronic fibroid tuberculosis,
Tuberculosis in the sensitized patient.

(*a*) Apical fibroid tuberculosis. (Fig. 8.)
Earliest findings in localized tuberculous pneumonia; if lesion extends, chronic fibroid tuberculosis develops. (Fig. 9.)

(*b*) Gelatinous and caseous bronchopneumonia with apical lesions. (Fig. 10.)

(*c*) Lobar caseous pneumonia with apical lesions. (Fig. 10.)

(*d*) Fibrous pleurisy—pleural exudate.

2. *Puerile or Primitive Tuberculosis:*
Syn. Childhood tuberculosis,
Tuberculosis in the non-sensitized patient,
Focal tuberculosis.

(*a*) Primary lesion and tuberculous nodes. (Figs. 2, 3.)

(*b*) Miliary tuberculosis. (Fig. 6.)

(*c*) Basal tuberculosis. (Fig. 5.)

(*d*) Tuberculous caseous broncho- and lobar pneumonia (without apical lesions). (Fig. 5.)

(*e*) Caseous pleurisy.

There have been so many classifications of tuberculosis that to-day there can be only two excuses for attempting a new one—either that the writer may frankly express the limitations of his knowledge, which means his ignorance, or that by such a sacrifice he may help someone struggling with the problem of the disease. I have hesitated many years before presenting this classification. It has been of help to me and my associates, and I finally formally present it to this Society. Its value lies in the description of the peculiar densities which are associated with each type seen upon the plate; the separation of the disease into the peurile and adult types, which has been so clearly presented by Opie,[3] also in emphasizing that these types are dependent upon the resistances of the economy, which differ greatly in the child and the adult. These are partially and indefinitely suggested by differences in the lymphatic system, hypersensitiveness and immunity.

At the very beginning of my work it was found that there were great differences between the plates of tuberculous children and tuberculous adults. It was a great satisfaction when in 1917 Opie proved that this difference was due to anatomical differences. This confirmed my unpublished work which showed that differences in the plates were due to differing lesions and not to imperfect *x*-ray technique.

It has been shown by Krause[4] that the tubercle bacillus grows very differently in sensitized and non-sensitized animals, and Col. Bushnell has brought a mass of evidence to prove that this holds good in man. He has also shown that non-sensitized adults of the aboriginal races suffer like children, and I have often seen children whose resistance was so great that they had definite fibroid fans containing well walled-off cavities.

It is, therefore, evident that age is only a partial factor, and that immunity or hypersensitiveness plays a part. The only method known of raising immunity is by inoculating an animal with the living tubercle bacillus. This has been done repeatedly by Webb, Krause and others in animals, and in congested communities all children receive it without expense—too often an overdose is administered. Thus before a child is ten he is usually sensitized, and has acquired a degree of immunity, and we may expect the characteristic adult fan lesions.

It is true that we have the adult lesions in children and that we have peurile lesions in the adult. Either of these transformation types argues a grave prognosis. Adult lesions in the child, unless very slight, argue a far advanced disease; and the puerile type in the adult argues little resistance unless it is healed.

The differentiating roentgen characteristic of such lesions is the tuberculous fan. These are found constantly in the adult type, and I wish here again to describe them because they have been so frequently misunderstood. Allow me to repeat. The fan is not necessarily a characteristic of tuberculosis. It is a characteristic of a limited lung lesion. It is dependent upon the septa of the lung which are arranged so as to divide the lung into numerous cones or triangular pyramids. These limit the extent of many lung lesions as effectively as the lobe limits lobar pneu-

monia. They form the secondary lobules of the lung. When a lesion with differentiating density develops within one or a number of secondary lobules it may be recognized upon the plate. Such lesions are found in lobular pneumonia, pneumonoconiosis, infarct and tuberculosis. The pathognomonic tuberculous lesion is found when we have two or more the bronchus. The septa are prolongations of the pleura into the lung and they prevent the spread of the lesion beyond their boundaries because they carry the lymph flow away from the adjacent lobules, and barring cavitation the tubercle does not pass over this boundary. The lesion may invade the adjoining lobule, but it does not pass through the

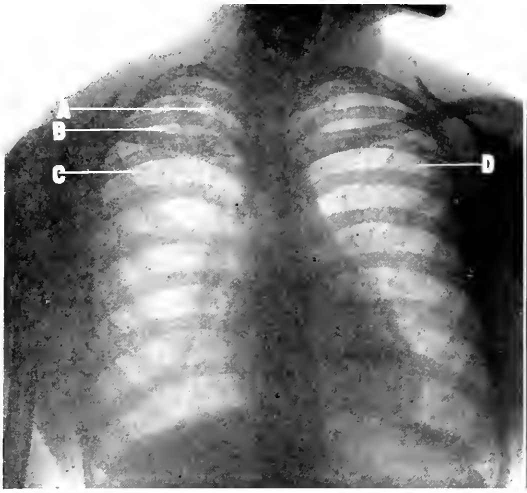

FIG. 8. No. 1075.—Adult type of tuberculosis showing definite "open" active apical fans involving vertebral first interspace trunk of upper right and second interspace trunk of upper left.
A. Right vertebral trunk.
B. Right first interspace trunk.
C. Right second interspace trunk.
D. Left second interspace trunk.

FIG. 9. No. 197.—Adult type of tuberculosis having definite fans of different densities.
A. Old lesion involving left first interspace trunk.
B. Recently active lesion involving left first interspace trunk.
C. Active lesion involving right first interspace trunk.

of these fans of differing density (Fig. 9). These densities may vary from a coarse interweaving to a faint cloud, to fine or coarse studding or to a complete blotting out of the lung structure. In advanced lesions the novice is unable to make out the fans, but they can usually be seen if the plates are carefully studied. Usually tuberculous fans form first in the upper part of the upper lobes.

I believe that I can amplify this truth if I digress and explain why tuberculous fans are of differing densities, how and why they differ from some other lesions and emphasize that primarily they are small and lie close to the periphery.

The early adult lesion is small because tuberculosis spreads very little by continuity but by the lymph-stream and later through septa. In a sensitized animal such as a man there is great exudation at the point of infection which floods this small compartment of the lung, but this does not spread beyond the boundary unless it goes down one bronchus and up another and floods another lobule. Thus, the early fans are usually small and their size is dependent upon the amount of exudate. I do not know why these fans should be so near the pleura, but they are found both upon the plate and upon section. Certainly the lymphatics must play a great part in this. Possibly these infections near the center and roots of the lungs have better lymph drainage. The densities of these fans differ because they are of differing ages, and the various pathological lesions, such a fibrosis, caseation, calcification and exudation indicate stages of development. The former

will be presented by various degrees of clouds and studdings; the latter by a very delicate cloud. Thus localized, apical pneumonia as seen after influenza may simulate the latter, but could not the former.

Malignant tumors, especially secondary sarcomata, spread through the lymphatics exactly as does tuberculosis, but they have no special affinity for the apices and they are not restricted by the septa. They spread very rapidly by continuity; thus secondary sarcomata often appear as spheres of increased density (Fig. 17). We may have a case of carcinoma which produces a mottling very much like caseous bronchopneumonia, but there are no apical fans (Fig. 16). If such a plate was caused by tuberculosis, then it would be classified under the puerile type, and we would look for a man who had been raised and had lived the greater part of his life in a sparsely settled country. The caseous pleurisies which are found in army hospitals often simulate malignancy.

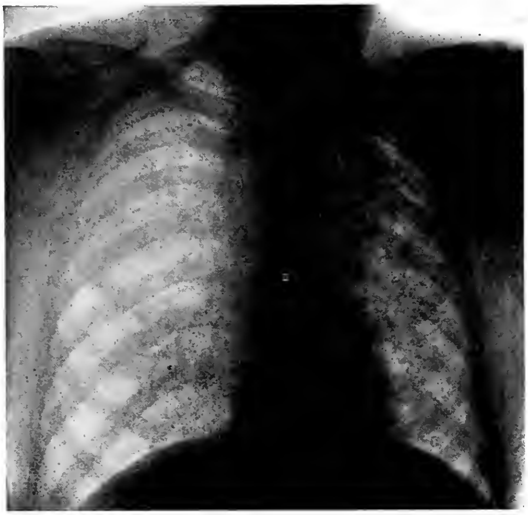

Fig. 10. No. 587.—Adult type of tuberculosis with old lesion in left apex and heavy caseous bronchopneumonia in lower part of the upper lobe and scattered throughout entire lower left lobe.

Thus, the slow growth of the tubercle, the restraining influence of the septa, the exudate around infections in sensitized animals, the lymph drainage, the location of the lesion, produce characteristic densities which can be accurately diagnosed in fully 95 per cent of all cases of adult tuberculosis if doubtful cases are excluded.

Thus I have presented the early and characteristic *x*-ray lesion of the most common form of tuberculosis—the fan—and I have tried to explain why the fan. But the fan does not embrace all the lesions of tuberculosis even as seen upon the *x*-ray plate as found in adult tuberculosis, and the apical fan is never found in puerile tuberculosis.

Let us now consider briefly the remaining types of adult tuberculosis and study their densities and distribution within the lung.

Here I wish to state that chronic fibroid tuberculosis is the result of many tubercles, many tuberculous exudates and many fibroid protective reactions.

Before going further let me quote from the lecture of Dr. Bunting. "There are just three lesions in the tuberculous lung: Tubercle, exudate and fibroid protective reaction." The tubercle may have three densities: early tubercle, caseation, calcification. Exudate may have three densities: serous exudate, cellular (caseous) exudate, calcification where encapsulated. When caseation breaks down we have a cavity with decreased density. The fibroid protective reaction gives a density in proportion to the fibroid tissue produced, modified by its age. The degree of density of the various tuberculous lesions progresses in the following order. Cavity; serous exudate, early tubercle; fibrous tissue; caseation; calcification.

After the apical lesion the most common lesion of adult tuberculosis is caseous bronchopneumonia. Its *x*-ray density is a coarse flocculent mottling (Fig. 10.) It is associated with old apical lesions, usually containing cavities. It invades the lower and middle lobes and the lower part of the upper lobes, and sometimes the apex opposite to an old lesion. It frequently can be seen scattered along a branch of the main stem bronchus suggesting raisins upon a stem. It may become confluent and produce pseudo-lobar caseous pneumonia. Then it takes on a fan shape. It is probably caused by aspirating droplets of sputum containing large numbers

of virulent tubercle bacilli into primary lobules.

The size of these densities varies greatly even in the same individual, but to a greater extent in different individuals. Sometimes they are so small as to suggest miliary lesions and again they appear as a filbert.

When the *x*-ray picture is hazy and the more extensive the lesion the more grave the prognosis. Caseous bronchopneumonia must be differentiated from acute bronchopneumonia. The latter lesions are usually much less dense and they are not associated with large apical lesions. Also the cases of caseous pleurisy found in the puerile classification have similar lung densities without

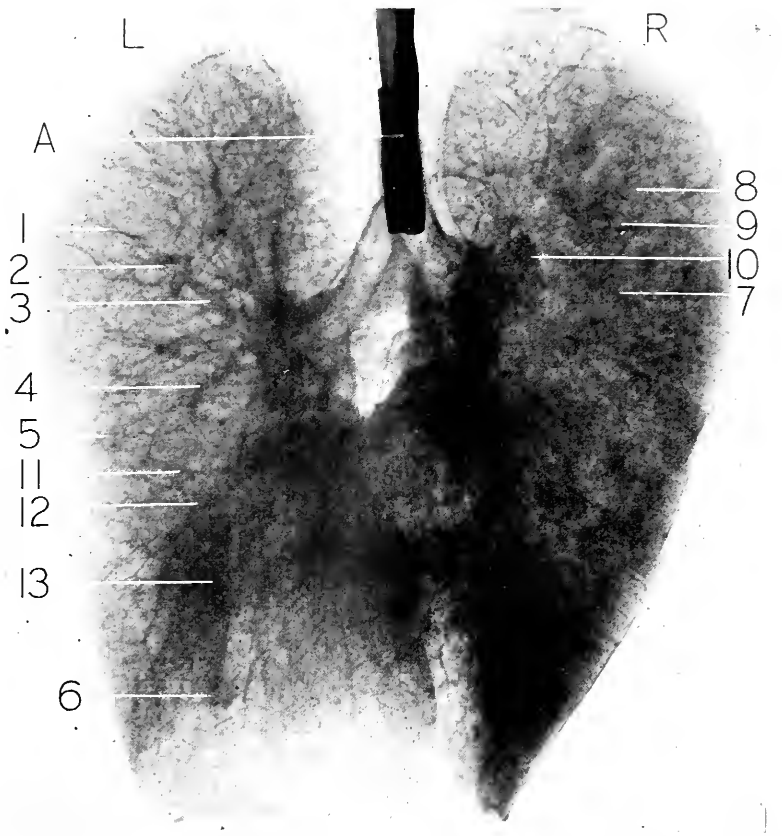

Fig. 11. No. 1096.—K. S. Illustrates heavy trunks, "peribronchial thickening" most marked in the upper left lobe, without tuberculosis. Infarct is seen in lower right lobe in area 6. (Numbers indicate sites of blocks removed for microscopic sections.)

lung appears as seen through a snowstorm, we are dealing with an acute active lesion or hemorrhage. Thus, when we see the picture of finely mottled caseous bronchopneumonia as through a snowstorm, we may suspect that we have gelatinous tuberculous bronchopneumonia or caseous bronchopneumonia complicated with an acute pneumonia. Caseous tuberculous bronchopneumonia may exist over a large area without causing any signs or symptoms, but always suggests a grave prognosis. The more acute and the apical lesions. Malignancy also must at times be differentiated, but here again we do not have apical lesions. Always we have the clinical picture, the history and physical signs to help to solve these knotty problems, and the roentgenologist has only to describe definitely and locate the abnormal densities with or without large apical tuberculous lesions, to give the clinician his all-important clue.

Lobar caseous pneumonia occurs in both adult and puerile types, but old apical lesions are associated with the adult type. It is fan-

shaped and may involve a lung or part of a lung. Its size and degree of density depend upon the number of secondary lobules involved. The character of the density is homogeneous and may be found in any part of the lung. Such lesions break down and cavitate rapidly. It is the predominant lesion in "hasty consumption" which precedes cavitation.

FIG. 12. No. 1653.—Massive lesion, probably the result of syphilis because of presence of 4 plus Wassermann. Sputum was negative for tubercle bacilli on numerous examinations and the density disappeared with injections of salvarsan.

Large areas of the lung may be so involved for months without causing severe symptoms. The principal sign is flatness. The prognosis is desperate, for this lesion will surely break down and rapidly cavitate. It is called hasty consumption because, although the lesions may have existed for some time, it is often only recognized shortly before death. The x-ray densities of early cases must be differentiated from unresolved pneumonia and pneumonoconiosis, and the history is our best aid. Later the diagnosis from the x-ray plates or sputum presents no difficulties, but the clinician must ever be on his guard. Acute tuberculous pneumonia with fever simulating frank pneumonia gives a similar x-ray picture with less density, and the roentgenologist may be as easily fooled as the clinician if we are dealing with a puerile type without apical lesions; but if we have a definite apical lesion the roentgen examination suggests the diagnosis.

Fibrous pleurisy and pleural effusion are frequently associated with pulmonary tuberculosis. They will not be discussed in this paper except to say that a small amount of caseation is frequently found in fibroid pleurisy of the adult type, and to call attention to the very different lesions which will be described under the puerile type.

I have now reached the puerile type in this classification and repeat that it is not found with apical fans, and that its classification is based upon a study of the entire lung field.

The early puerile lesion as seen upon an x-ray plate shows a heavy trunk and large hilum shadows with possibly a small cap at or near the distal end of the trunk. Such foci are usually seen within the midlung zone. Sometimes enlarged pulmonary or bronchial nodes are seen (Figs. 2, 3). Unfortunately such a picture may be obtained following many diseases, and I know of no roentgen markings which are sufficiently characteristic to justify a diagnosis of tuberculosis from these x-ray densities. Opie and Gohn[6] have carefully described these lesions. When healed and calcification has developed they are easily recognized, but that is usually long after their clinical significance has passed. Thus, so far as I know, primary and nodal lesions in a child cannot be recognized from the plate unless they contain calcification.

Acute miliary tuberculosis deserves special consideration. I have classified it with the puerile types without fans, but realize that it does occur at the end of the disease as well, and then usually with fans. I believe that it is the result of lack of immunity or the loss of immunity. Thus we find it associated with old healed lesions in which I believe the immunity has been lost, and without such lesions I presume we have never had much if any immunity. I have specimens of miliary tuberculosis without old lesions from cases over twenty years of age, but class them in the puerile type.

The x-ray picture is that of fine studdings more or less evenly distributed throughout

all lobes (Fig. 6). Such a picture is very characteristic, but not pathognomonic, for some such plates cannot be differentiated from pneumonoconiosis, and we must again consider age, clinical picture, and history. Only at the end of the disease will the physical signs help. Many cases of healed miliary tuberculosis are being found by our more general use of the x-ray (Fig. 7). This diagnosis is only justified when the subject is well, has had no exposures to pneumonoconiosis and the calcifications can be definitely determined within some of the tubercles as seen upon the plate. The prognosis of miliary tuberculosis is very grave but cases do recover. Basal tuberculous lesions are rare. They do exist, and as they are most common in children and have no apical fans, I have classed them with the puerile types. They are pneumonic in character and sometimes have the bronchopneumonic distribution around their edge, but I have never seen the raisin on a stem distribution. They are very difficult to diagnose and I always wait for the bacillus to be found before making a definite diagnosis. This is a definite limitation and reduces the percentage of correct diagnosis, but it is safe. It is much better for the roentgenologist to locate and describe the lesion and leave the diagnosis to the clinician. Basal lesions must be differentiated from lung abscess and unresolved pneumonia. The clinical symptoms will usually differentiate it from lung gangrene. The prognosis is grave, but cases recover.

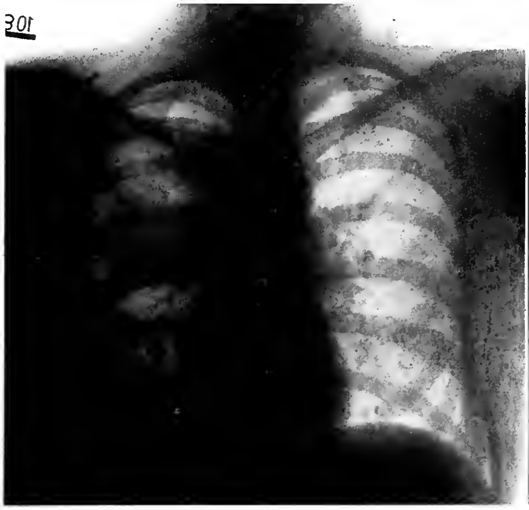

Fig. 13. No. 1325.—Massive lesions due to unresolved pneumonia of influenza which clearel up slowly. This must be differentiated from massive lesions of syphilis. In this case there was no syphilitic history and patient received no salvarsan.

Fig. 14. No. 1325.—Four months later. Shows massive lesion of unresolved pneumonia now cleared.

The puerile types of caseous lobar and lobular tuberculous pneumonia only differ from the adult type by the absence of apical lesions (Figs. 4, 5). The prognosis is very grave or desperate in either type, and length of life depends most upon the extent of the lesion.

Caseous pleurisy like miliary tuberculosis may occur in individuals over twenty. I believe that it results from lack of immunity. The x-ray picture is that of empyema associated with caseous bronchopneumonia without apical fans. There are various degrees of caseation within the pleura associated with fibroid pleurisy. In the adult type caseation is rare. In the puerile type caseation predominates. I have seen solid cheesy masses at the apex and base which measured 5 cm. in thickness. The extent to which the parietal pleura is involved is most extraordinary. The end is invariably fatal and rapid, but the patient neither feels nor looks

sick. Usually, if the chest is tapped, a little fluid is removed, but when aspirated a second time little is found.

The greatest helps I receive from this classification are prognosis and the differentiation of tuberculosis from other diseases —hence, intelligent treatment. X-ray classifications have been given by Cole,[7], Brown,[8] Waters,[9] and Heise.[10] They each have value,

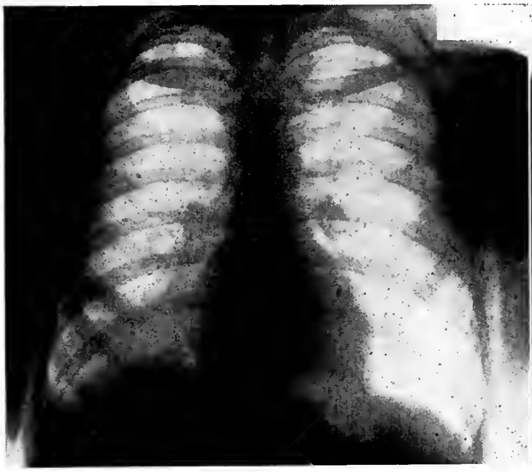

FIG. 15. No. 1313.—Bronchiectasis in right base.

FIG. 16. No. 230.—Primary carcinoma of lungs. Proven by autopsy.

but they do not help me with prognosis nor with pathological differentiation. They all deal with the extent of the lesions. This is most important after we have definitely determined the pathological character of the lesions. An old well walled-off fibroid lesion will always be a handicap, but such patients often live long, to die of other diseases, whereas a small pneumonic fan of active tuberculosis which is only seen upon the plates with difficulty usually causes an early death unless brought to immediate arrest by the utmost care.

Again, one entire upper lobe may be so contracted by scar tissue as to lie above the second rib in front and the third dorsal spine behind, and although a whole upper lobe is destroyed it would be classed as only moderately advanced. I know that this classification is neither perfect nor complete, but even in its present form it has been of great help and has enabled us to clear up many difficult problems.

THE DIFFERENTIAL DIAGNOSIS OF A FEW DISEASES WHICH, OWING TO THEIR COMMON OCCURRENCE, MUST RECEIVE SPECIAL CONSIDERATION

The first of these is syphilis of the lung. That such lesions are not uncommon is the belief of every clinician. Every large x-ray clinic can show cases with massive increased densities which have cleared up under antisyphilitic treatment (Fig. 13). It has always been my belief that tuberculosis was often complicated by syphilis and that both roentgenologically and pathologically the tuberculous lesions obscured the syphilitic infection. In my judgment this subject can never be closed until someone has demonstrated the presence or absence of the spirochete in the tissue. But, however that may be, we have dense lung lesions partially simulating tuberculosis upon the plates which clear up wonderfully with salvarsan. Therefore, when we have an undiagnosed density within the chest, syphilis should be thought of. To find these densities, routine x-ray examinations are necessary.

I have previously called attention to the frequency with which heart lesions, especially mitral stenosis, may simulate pulmonary tuberculosis, and wish to state that no examination of the lung is complete

without a heart examination and stereoscopic *x*-ray plates.

Pneumonoconiosis is deservedly receiving more and more attention all the time. There are two main forms of this—organic dust, and inorganic dust. The latter frequently suggests miliary tuberculosis and later in the disease may produce massive fans of great density, while organic dust produces large fans simulating pneumonia. Often the history and clinical condition of such patients must be ascertained before making a diagnosis.

Pulmonary infarct may closely simulate tuberculosis, especially the basal lesions, and must always be considered.

Finally, this review of over 10,000 chest examinations shows the need for more general use of the *x*-ray in studying the lungs. In tuberculosis clinics this examination should be routine, and if it were more used in our general hospitals it would not be long before many problems, such as syphilis of the lung, would be more fully understood. The greatest value of the routine *x*-ray examination lies in its ability to yield definite data in the absence of definite physical signs.

Dr. John Skavlem has been associated with me in a large part of this research, and I am especially indebted to him for arranging the illustrations and covering the bibliography.

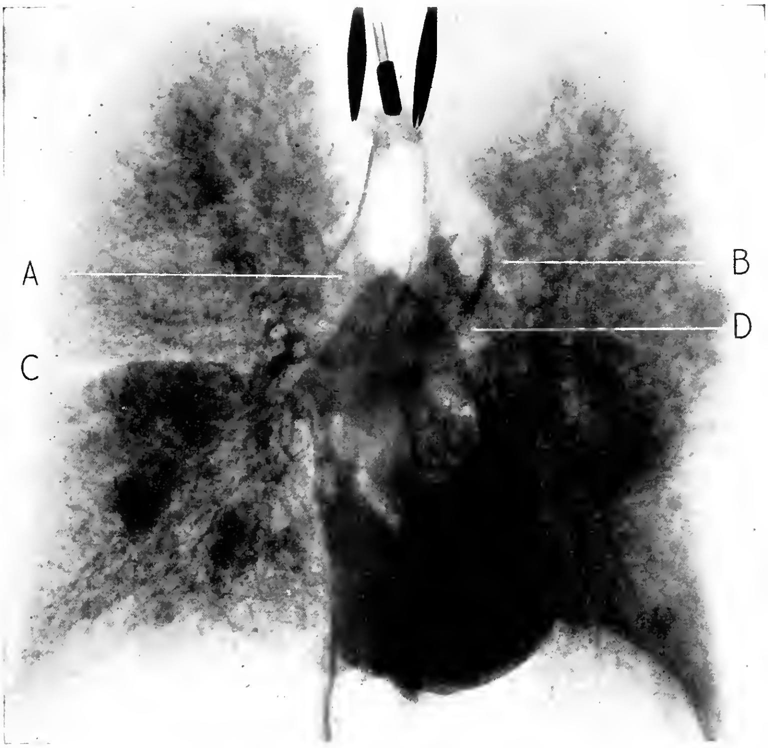

Fig. 17. No. 918.—Melanotic sarcoma of lung. Proven by autopsy.

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DISCUSSION OF ARTICLES BY DRS. JARVIS* AND DUNHAM

Dr. H. K. Pancoast. This is a subject in which I have been very much interested for a number of years, and we have had the privilege of examining several hundred cases of pneumoconiosis, the examinations including six or eight observations. This demonstration has been particularly interesting to me because of the class of patients involved, and because the appearances have been different from those observed in any other dust inhalation I have seen. One must understand the pathology of this condition in order to interpret the roentgen findings. The consensus of opinion seems to be that the roentgen findings are due to two important things: the acute irritation resulting from the presence of dust and the appearances that may follow that, and then the appearances which follow the end result of fibrosis.

The condition of pneumonoconiosis is essentially one of fibrosis. I never have seen the appearances show so markedly as they have in these plates exhibited this morning. We have examined more potters than any other class of men, and they show more changes in their lungs than any other class I have seen, except the hard rock miners. We have examined those potters while still in the potter work, and I have examined potters who have not worked for several years on account of disability from the so-called "potters' asthma." They do not change in any respect. The appearances are always the same. Unfortunately we have never examined stonecutters, but I imagine the ordinary stonecutter would show very much these same changes unless possibly their work is more handwork and they do not use the electric drill so much. The appearances, of course, depend on the inorganic dust. The organic dust does not produce changes of any kind.

It is interesting to note the prevalence of tuberculosis in these cases. Dr. Jarvis did not say much about tuberculosis in connection with the granite-workers in the cases we have just seen. Potters, asbestos-workers and metal-grinders all show marked changes, but tuberculosis does not seem to exist in the same percentage of cases as in ordinary individuals. We do not know why it is unless because of the production of fibrosis; but it is a well-known fact that in the hard rock miners, that is, the coal miners in South Africa and the copper miners of the Southwest, tuberculosis is more prevalent. This is brought out by the Public Health Bureau, I believe. I have had the opportunity of going over a large number of their plates, and tuberculosis is more prevalent among these workers than in the average run of individuals, and it runs a rather acute course. This does not seem to be particularly due to hygienic surroundings, or lack of them. We believe there is something about the character of the dust which has some influence over the susceptibility to disease; and I imagine tuberculosis is more frequent in granite-cutters than in ordinary individuals.

Dr. Jarvis. No, we found it less prevalent.

* A roentgen study of dust inhalation in the granite industry. D. C. Jarvis, M.D. Am. J. Roentgenol., May, 1921, p. 244.

Dr. Pancoast. Is that so? At any rate, in the copper miners of the West and the coal miners of South Africa, it is quite prevalent.

We have always found, with very few exceptions, that the beginnings of the second stage of pneumoconiosis, that is, the mottled appearance, starts on the right side, around the central portion of the lung. We have always taken this to be due to mechanical causes, that is, more air goes into the right lung, the right bronchus is larger, and the dust particles, of course, are more profusely distributed. It is certainly interesting to see the distribution you have in these cases, and particularly as it is due, as I think you said, to the suppression of breathing in certain areas from pressure from the electric drill. This is, of course, another mechanical factor, and one can readily understand how certain areas of the lung might receive more dust than others because of such factors.

Dr. Percy Brown. Many years ago, before I entered the roentgenologic field, I had occasion to make a series of visitations and statistical observations for an insurance company upon the question of pulmonary tuberculosis as between the dry-cutters (the granite-cutters) and the wet-cutters, or free-stone cutters. My comparative observations were made more in Massachusetts in the area of Quincy than in the Vermont area. Those observations, crude as they probably were, tended markedly to show a great increase in final mortality in those who worked free-stone in the wet process than those who worked in granite. In those days, at least, most of the free-stone cutters or that portion of the free-stone industry whch I observed, was shipped from Maine to Boston, and the cutting was done by hand rather than by machine, as I imagine it is done now. I should like to ask Dr. Jarvis if he has, by chance, made any comparative observations among dry-stone and wet-stone cutters.

Dr. George C. Johnston. I was very much interested in the remarkable recovery of some of these men, that is the change in the appearance. I shall be very, very careful in the future about making diagnoses of pulmonary carcinoma until I have made inquiries as to whether the patient is a granite-cutter, or rather I won't ask him, I will just look at his hands, and see whether or not he is a hard rock worker, because I cannot tell, and I will have some fun with any of you who think you can differentiate between early pulmonary carcinoma and some of those plates of Dr. Jarvis', because you can't do it.

The reason these men do not suffer from pulmonary tuberculosis when they get their lungs full of this dust is because of the fibrosis which follows. If these men were working in the depths of the earth, in the damp atmosphere, at a high altitude, as the hard rock miners do, they doubtless would develop tuberculosis, too; and as for the copper miners, if any of you have ever been in a copper mine, you will know that they ought to wear a diving suit. That is probably the reason why the hard rock miners of the West suffer from tuberculosis where the granite-workers do not.

Another reason why these men do not develop tuberculosis is because the sole defense of the human organism of the lung against tuberculosis is the fibrotic change produced. It would almost seem that the ideal way to cure a man of tuberculosis would be to get him a job as a granite-cutter. When I am asked to give an opinion in the prognosis of a case of tuberculosis, I can give a very fair one, and get away with it every time and base my opinion as to his reaction to his disease on the amount of fibrotic tissue present. We can have a lung riddled from top to bottom with cavities and caseations and no fibrosis in that lung, and I know the case is hopeless, whereas the entire lung can be riddled with cavities, etc., but showing an extensive fibrosis, and I know that patient will probably live long enough to infect and kill everybody in his vicinity.

Dr. Carlos Heuser. In Buenos Aires we see many cases similar to these in people who work in grain—alfalfa, wheat, rye, etc., who carry the grain in from the fields in sacks on their backs. They are constantly breathing the dust from this grain. In many cases, small particles of the grain are inhaled into the lung, and after fifteen or twenty days, a small abscess develops, and many of them die.

Dr. Kennon Dunham. I don't know anything that has been more interesting to me than this work of Dr. Jarvis'. It has been my privilege to go over a great many, in fact, practically all, of his plates. I want to say that while he comes to us as a rank outsider, he

certainly brings us something of the utmost value. As Dr. Johnston said just now, I will defy any of you to differentiate some of those lesions from carcinoma or sarcoma of the lung, and I will defy any of you to take some of those plates and differentiate them from pulmonary tuberculosis. Nothing have I seen which is so striking as the plates which the Doctor has brought to us at this time. If you can persuade him to show them all to you, you will not go away without learning something. Remember he is not an *x*-ray man—he is just an eye, nose and throat man, but he is living with a great problem in front of him day after day. His friends are down with this disease. And he has come forward with these plates and other examinations and shown that what was thought to be tuberculosis is probably not tuberculosis at all, and the dreaded tuberculosis in these men is not to be feared to any great extent—probably not so many, as Dr. Pancoast found in his experience, as are dying of tuberculosis in other communities.

Now let us take up the question of the dust. It has been said that organic dust does not leave any lesion. Certainly it leaves no lesion comparable to the ones we have just seen, but as our friend has said with regard to the alfalfa and other grains, they do give trouble in the lung, but the lesions are entirely different. They do not produce lesions simulating these fibrotic changes, and we must learn to divide these pulmonary dust infections from the organic dust, from those caused by inorganic dust.

Now, there is something peculiar about this granite dust that is different from anything I have seen. The anthracite coal gives an entirely different lesion, as one of our members has enabled me to learn. That particular lung we have sectioned, and found that the fibrosis was limited to small areas, and those plates simulated pulmonary tuberculosis. The locations of these fibrotic areas are exactly where we believe tuberculosis begins, that is, in the lymphatic tissue of the lung, and in the crotches of the bronchi and vessels, just where we find pulmonary tuberculosis. The pathology which underlies these cases which you have seen to-day must be very unusual, because of the catarrhal conditions which are produced, and the fibrotic conditions which are found there afterwards. I think you have in that disappearance—which is a most wonderful thing—an effort by the bronchi to get rid of this frothy expectoration, but the lymphatics must take care of the rest, so we have this movable density which comes and goes, which is different from anything any of us, so far as I am aware, have seen before. It leaves the old fibrotic changes to stay there forever.

All of the plates were not presented to you by Dr. Jarvis for lack of time, but I am sure that he will be glad to demonstrate them to any of you who will see him, and some of them are almost identical with the changes of tuberculosis.

Dr. Wm. H. Stewart. I am wondering whether Dr. Jarvis' paper does not answer the questions of some of the discussions on my paper, viz., that if granite dust in such quantities can remain thirty years in the lung and produce only a fibrosis, why a small amount of bismuth cannot remain in the lung without doing any harm?

Dr. Jarvis. I am very thankful for the way in which this paper has been received. In reply to Dr. Brown, I have never made any comparative examinations. My geographic location is such that I do not come in contact with these wet-workers.

Dr. Stewart, when I read your title, I said, "Of course, that is possible."

These densities, we think, are composed of three factors, one constant and two inconstant. The constant is the residual fibrosis. The first inconstant is the dust which is moved on by the lymphatics, and the second inconstant is what we call the edema. The edema disappears after a time, but the residual fibrosis will always show.

GUNSHOT INJURIES TO THE BRAIN

REPORT OF ELEVEN CASES WITH SPECIAL REFERENCE TO THE ROENTGEN LOCALIZATION FINDINGS*

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QUINCY, ILLINOIS

LIVING cases of foreign bodies in the brain are so infrequent that the author feels that those which passed through our large military hospitals during the late war should not go unreported. The medical literature is scant on the end results of groups of patients who have been observed for many months after the initial trauma. Twelve such cases passed through U. S. A. General Hospital No. 28, Fort Sheridan, Ill., from the time of its opening as a general hospital in the late fall of 1918 until the early fall of 1919, when the writer was discharged. He has been able to follow up eleven of them, and it now averages a little more than a year and a half since these patients received their trauma.

Before proceeding with a history of the individual cases, a few words as to the roentgen method used to localize the foreign bodies might prove interesting.

Due to the great density of the skull, fluoroscopic localization methods to determine the depth of small foreign bodies are frequently difficult. Although the writer has used the Strohl method and the simple tube-shift fluoroscopic method, in some of the cases more satisfactory results were obtained with the old tube-shift plate method. With this method lateral and postero-anterior plates were first made and then the foreign body located under the fluoroscope, a mark being placed upon both sides of the head opposite the foreign body. In each case the foreign body was located from both sides of the head, and of course in the central ray. Following this, the diameter of the head opposite the foreign body was obtained by means of calipers. Then the depth of the foreign body was determined by the tube-shift plate method, great care being taken to have the part of the head which was marked as being opposite the foreign body in contact with the plate. Since the depth of the foreign body was localized from both sides of the head, and the diameter of that portion of the head had already been determined, it was easy to have an accurate check as to the correctness of the localization findings.

Having obtained the depth of the foreign body beneath the skin, and wishing to ascertain its anatomical location, the following method was pursued. The postero-anterior and lateral diameters of the head having been obtained with calipers, a teleoroentgenogram of the head (tube plate distance 6 to 7 feet) was then made, the side of the head containing the foreign body being nearest the plate. Such a plate shows a minimum amount of distortion, the head appearing approximately normal in size if the 7 foot distance is selected. The anatomical localization is then completed by a comparative study with the sections of the Eycleshymer-Shoemaker *Cross Section Anatomy.* (In this atlas all the head sections are shown as two-fifths the natural size. Key-Figure 2 of the Atlas contains a lateral view of the head which compares very favorably with a teleoroentgenogram of this part.) A line is drawn on the teleoroentgenogram to represent Reid's base line (from the lower margin of the orbit to center of the external meatus acusticus).This corresponds to a similar line, known as Section 10 in the Atlas. Another line is then drawn on the teleoroentgenogram, perpendicular to Reid's base line, passing through the foreign body. The distance

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY.

this perpendicular line extends from the line representing Reid's base line to the foreign body is measured. The distance is also measured on Reid's base line between the external meatus acusticus and the point where the perpendicular line begins. Having obtained these measurements, they are compared with similar measurements on Key-Figure 2 of the *Cross Section Anatomy*, but since these sections are only four-fifths the natural size, a proportionate reduction must be made. This is entirely overcome by drawing a scale on an *x*-ray film and then fixing it without developing. This gives a transparent celluloid scale that is very convenient. The scale is so drawn that each square is 8 mm. in size, one such square corresponding to each centimeter. Having obtained the location of the foreign body on Key-Figure 2 of the *Cross Section Anatomy*, and noting the distance it is on this figure from either the anterior or posterior extremity of the head (which of course will be in the median plane), we now turn to that plate of the Atlas which shows a transverse section of the head at that particular level.

We already know the distance the foreign body is from either the anterior or posterior extremity of the head at the level of the median plane. This distance is measured off on the section. The foreign body then lies in a plane at right angles to this and we merely measure off its depth beneath the skin surface at this level, which gives its approximate anatomical location.

The foregoing method may appear quite cumbersome, but each step mentioned is absolutely necessary if accurate deductions are to be made. The head being oval in shape makes localization methods more difficult than when flat surfaces alone are considered. Due allowance must be made if the size of the head is much larger or smaller than that of the average size. However, since the size of the head in the Atlas is known and that of the patient has been determined by the calipers and teleoroentgenogram, little difficulty is noted. In the writer's personal experience, the diameter of the twelve adult male heads examined did not vary over 1.5 centimeters at the most. A description of the individual cases follows;

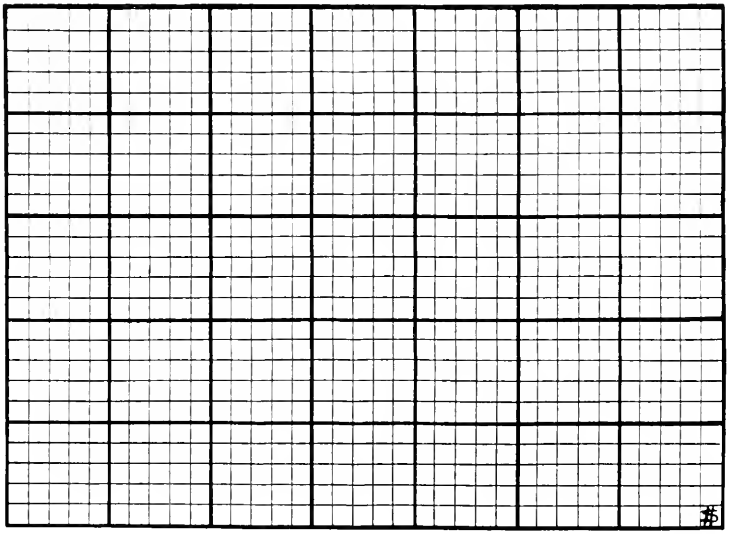

FIG. 1. Square Centimeter Scale for Eycleshymer-Shoemaker *Cross Section Anatomy*.

CASE I. Admitted to hospital February 17, 1919, suffering from acute cellulitis of the right hand due to striking guardhouse door while under arrest for intoxication.

White; age twenty-one; weight 155 pounds; occupation, machinist before entering the service. On February 22, 1918, in

civil service, he was shot in the head by a 22 caliber revolver; he immediately became unconscious, but in a few minutes recovered and walked to the hospital with a friend. Two weeks after entering the hospital he was operated upon, but the bullet was not found. Since being shot the only difference he has noted in himself is that he has not been so active, is not so pugilistically inclined and has occasional attacks of vertigo. was negative. The family history was negative.

Roentgen Findings, April 30, 1919.—There is a circular bony defect about 2 cm. in diameter situated in the squamous part of the right temporal bone about 3 cm. anterior and 2.5 cm. superior to the external meatus acusticus.

There is an irregular shaped metal fragment, about 1 x ¾ x ½ cm. in diameter

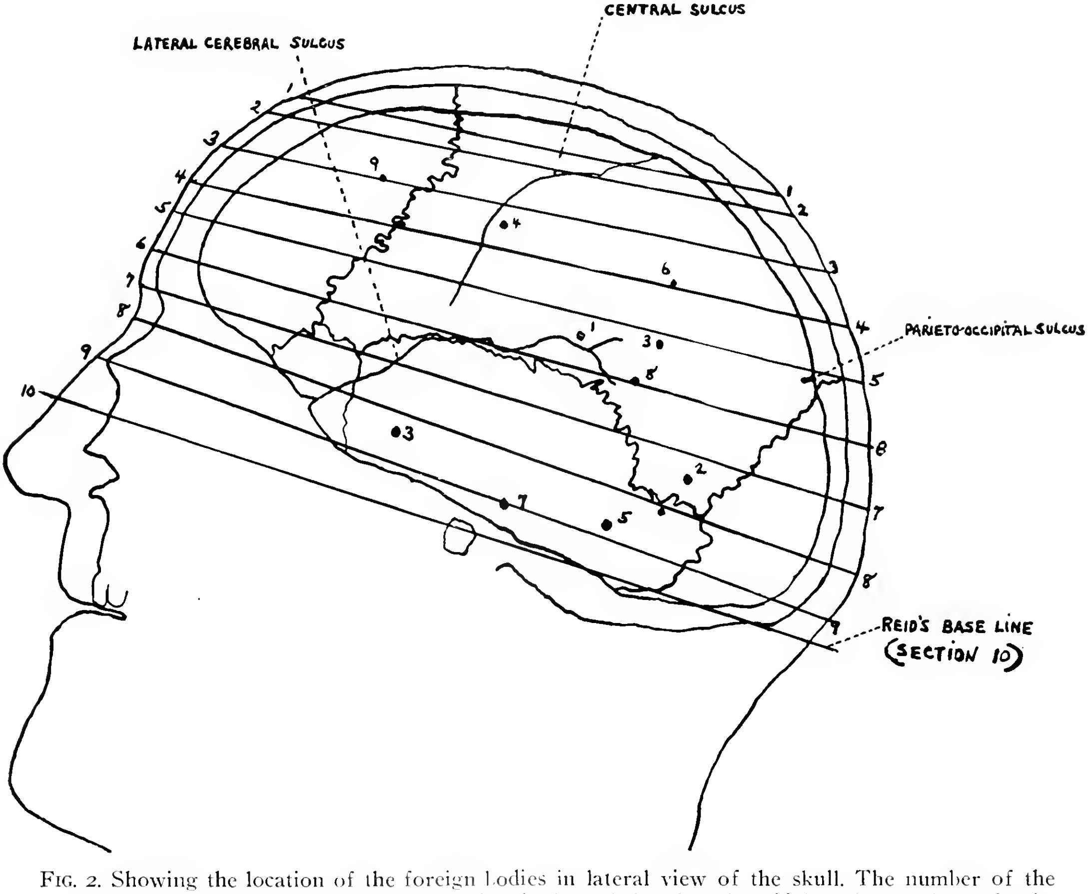

Fig. 2. Showing the location of the foreign bodies in lateral view of the skull. The number of the case is marked at the site of the foreign body and the plane in which it lies as shown in the *Cross Section Anatomy* is illustrated by the transverse lines which are numbered and called sections.

Upon examination a semilunar shaped scar was present in the right temporal region about 4 cm. anterior and superior to the external meatus acusticus. Immediately below the scar a distinct small depression was felt which pulsated. The right supratrochlear and axillary glands were enlarged and the right hand presented an acute cellulitis. Other than this the physical examination

situated 8 cm. vertically beneath the skin marks on the right and left sides of the head with the head in a true lateral position, patient lying on his side. It is therefore in the mid-sagittal plane. It is situated 1.5 cm. posterior and 6.5 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical localization corresponds to the

superior part of the splenium of the corpus callosum, probably projecting into the longitudinal fissure. Some metallic dust is seen at the lower margin of the bony defect and in the brain substance in the path to the large metal fragment. It is situated opposite the lower central part of the parietal bone about 1 cm. above the squamosal suture. The location corresponds to Section 5 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 7.5 cm. from the posterior surface in the median line.

Comment.—The interesting point concerning this case is the absence of any symptoms for fifteen months after the onset. The patient states that he never had any paralysis following the injury. It is clearly evident that the bullet passed through the entire right temporal lobe to reach its present location, yet it has not caused any symptoms, except for the initial trauma. The patient wanted to have it removed, but his reasons were purely psychological. Due to the extreme depth of the foreign body, removal was not attempted. He was observed for two months and was finally discharged from the service in May, 1919, due to repeated drunkenness and absence without leave. Mentally he appeared somewhat dull and possessed with little will power, but it is doubtful if the foreign body had anything to do with this. His education included six months of high school work.

In a letter received from this patient dated March 15, 1920, he gave a history of two distinct Jacksonian convulsions, one in May, 1919, and the other a few days before writing the letter. He also stated that at times he had vertigo, complained of a strange feeling in his head, as if it were full, and said that at these times he could not judge distance very well. This case is very interesting in that the patient after having had practically no symptoms from his foreign body for fifteen months developed a Jacksonian convulsion, which again developed ten months later.

Case II. Admitted to hospital, April 3, 1919, suffering from gunshot wounds of head and both legs, having been transferred from over-seas.

White; age twenty-seven; weight 162 pounds; occupation, machinist before entering service. On September 28, 1918, was inflicted with multiple wounds at Verdun. Following a gunshot wound of the head received at this time, he suffered from a complete right hemiplegia. He had nearly entirely recovered from this and the only symptom at the time of admission was slight weakness of the right arm.

Upon admission his general condition was good. There was a small depression in the anterior part of the left parietal region, 4.5 cm. from the sagittal suture. This was covered by a scar. There was also an old penetrating gunshot wound of the right leg, resulting in a fracture of the lower third of the tibia, which was healed and in good position, and an old gunshot wound of the upper third of the left leg which was healed. The family history was negative, but the soldier gave an alcoholic history.

Neurological Findings, May 1, 1919.—"Right-sided hemiparesis with reflex changes incident to pyramidal tract involvement of the left hemisphere; gives history of an aphasia; slight word-memory loss; is depressed over fact that he only received 20 per cent disability, and has marked emotional instability; otherwise no mental condition was found." (The final diagnosis of the Ward Surgeon was: Gunshot wound left parietal region with fracture of the skull; slight depression; healed. Gunshot wounds of right and left legs were also described.) Patient was discharged May 14, 1919.

Roentgen Findings, April 9, 1919.—There is an oval-shaped bony defect about 1.5 cm. in its greatest diameter, in the anterior-superior portion of the left parietal bone, about 5 cm. from the median line. There is some increased bone production at the lower margin of the bony defect.

There is an irregular-shaped metal fragment, about 1 x ½ x ¼ cm. in diameter, situated 5.2 cm. vertically beneath the skin mark on the right side of head, the patient lying on his left side with head in a true lat-

eral position. The surface markings correspond to the posterior-inferior angle of the right parietal bone immediately above the asterion, being 2.3 cm. superior and 5.7 cm. posterior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements.

The anatomical localization is deep in the lingual gyrus of the right occipital lobe. A very small metal fragment 1 mm. in diameter is seen in the brain on the left side near the bony defect in the path to the large metal fragment. The location of the large metal fragment corresponds to Section 7′ of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 4.75 cm. from posterior surface and 5.2 cm. from the lateral side.

Comment.—This case is interesting in that the metal fragment passed through the left parietal lobe to reach its location in the right occipital lobe. It is apparently causing no symptoms in its present location: the symptoms that were produced were due to the damage inflicted to the motor area on the left side at the seat of entrance.

The last heard from this patient was on April 12, 1920, at which time he complained of paresis in the right side together with some paresthesia. Although no Jacksonian attacks have been evident, he says, he frequently complains of great pains in his head. He also has vertigo at times and his general health is not good. In regard to his eyesight, he states: "Not very good, and tears run out of my eyes and I get dizzy." It would be interesting to know more definitely concerning the eyesight, for the location of the foreign body is in one of the visual receptive centers.

Case III. Admitted to hospital December 25, 1918, suffering from gunshot wounds of the head and right thigh.

White; age twenty-seven; occupation, tailor before entering service. On October 5, 1918, he received multiple wounds of the head and right thigh from a high explosive shell. He was unconscious for three days following the trauma, during which time his head was operated upon, and a metal fragment was removed from the thigh. Upon regaining consciousness, the left arm and left side of face were entirely paralyzed. The left leg was not affected. Both face and arm have been gradually improving and he has always been able to talk. Mentally he was not affected, except by a slight loss of memory at times.

Upon admission his general condition was

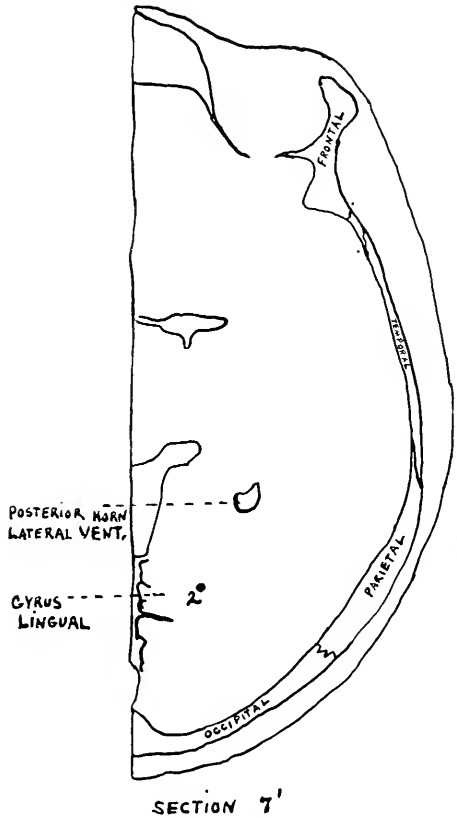

Figure 3.

good; there was a large oval depression in the upper part of the forehead on the right side which pulsates; there was an operative scar beginning 2 cm. to left of median line in frontal region and 3 cm. above supra-orbital margin. It extends circularly upward to end 3 cm. to the right of the median line. A depression is present which pulsates. The depression begins 4 cm. above the right supra-orbital region and extends to the median line. There was a mild degree of left facial paralysis with spastic paresis of left arm. Mentally he appeared clear.

Neurological Examination, March 6, 1919.—"There is some paralysis of left hand; can move all muscles of forearm but extension of fingers and rotation is slow and difficult. Reflexes spastic and some atrophy of pronators, though nutrition of arm is otherwise good. Conclusion: There is some thickening of membranes over right prefrontal area which is gradually softening."

This patient was difficult to handle. He was frequently absent without leave. His paralysis improved very much. He had several Jacksonian attacks. No attempt was made to remove the foreign bodies, because of their depth. On May 11, 1919, a bone transplant from the tibia was made to fill the defect of the skull. This was very successful.

Roentgen Findings, January 18, 1919.—There is a somewhat circular-shaped bony defect, about 3.5 cm. in diameter, in the middle portion of the squamous part of the frontal bone on the right side, extending to the mid-sagittal plane. Some bony attempt to close the gap is present.

An irregular-shaped metal fragment about 1 x 1 x ½ cm. in diameter is seen, situated 6.6 cm. vertically beneath the skin mark on the right side of the upper portion of the head, the patient lying on his side with the head in a true lateral position. The surface markings correspond to the lower central portion of the right parietal bone, being 3.25 cm. posterior and 6 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical localization is in the posterior part of the precuneus of the right parietal lobe, about 1 cm. from the mid-sagittal plane. The location corresponds to Section 5 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 5.5 cm. from the posterior surface and 6.6 cm. from the lateral side.

Another irregular-shaped metal fragment, about ¾ x ¼ x ¼ cm. in diameter, is seen situated 5.2 cm. vertically beneath the skin mark on the right side of the lower part of the head, the patient lying on his side with head in a true lateral position. The surface markings correspond to the anterior part of the squamous portion of the right temporal bone, opposite the sella turcica, being about 3 cm. anterior and 2 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical localization is deep in the right temporal lobe, opposite the middle temporal gyrus and anterior to the lower

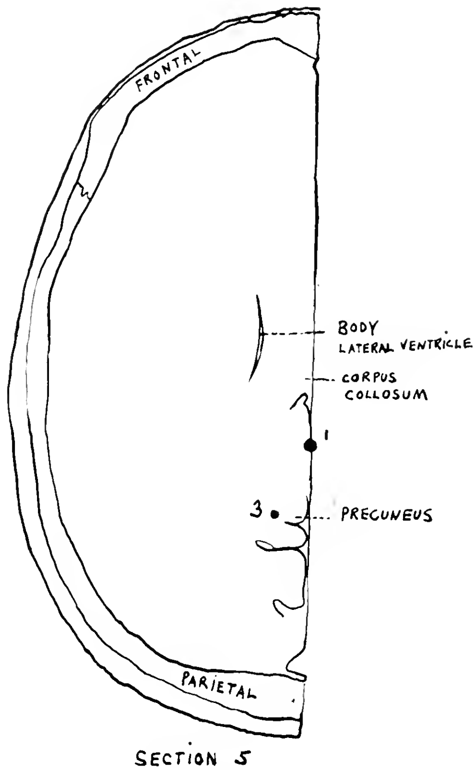

Figure 4.

part of the inferior horn of the lateral ventricle.

The location of the foreign body corresponds to Section 8′, Eycleshymer-Shoemaker *Cross Section Anatomy*, being 11.5 cm. from posterior surface and 5.2 cm. from the lateral side.

Comments.—Both foreign bodies passed through the right frontal lobe to reach their present situation in the right parietal and temporal lobes respectively.

On April 19, 1920, the patient reported that his left arm was still paralyzed and that

he has had light Jacksonian convulsions once a month in spite of constant bromide medication. He stated that he tired very easily and could not stand excitement.

Case IV. Admitted to the hospital April 13, 1919, suffering from a gunshot wound of the head, having been transferred from Camp Sherman.

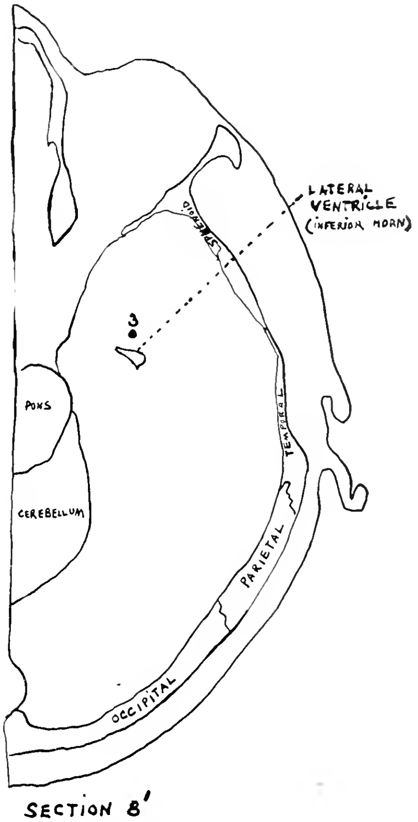

Figure 5.

White; age, twenty-four; weight 160 pounds; occupation, school-teacher before entering service. On October 5, 1918, at Verdun, he was hit in the left side of the skull by high explosive. He did not become unconscious but developed a right hemiplegia. He was operated upon shortly after and several metal fragments were removed from the wound, but the wound continued to drain. He was transferred from overseas to Camp Sherman, and on January 12, 1919, developed his first attack of epilepsy. He was operated upon January 21, 1919, to secure better drainage. Two weeks after the operation he had another attack and in five more weeks still another. On April 2d another operation was made, a piece of abdominal fat being transplanted to relieve brain irritation and dural adhesions. During this time the paralysis of the leg and face gradually improved, but the arm showed little improvement.

He was admitted on a litter, his general condition being good. There was some disturbance in speech and a loss of bone substance in the superior part of the left parietal region which was draining slightly. A right hemiplegia was present, which had improved greatly except the arm. A mild infection was present on the abdomen where the fat transplant had been removed.

Neurological Findings.—"Deep reflexes increased on the right side, exhaustible ankle clonus; Babinski on right; cremasteric reflex diminished upon the right; pupils normal; moderate spacticity and paresis of right side of face, arm and leg. There are practically all movements possible, but weak apraxia and astereognosis upon the right side is present. Can write with the left hand but misspells words. Slight association aphasia. No defect in visual field. No cranial nerve palsy. Jacksonian fits, beginning in right hand. Diagnosis: Cerebral lesion in left Rolandic area with diffuse lesion subcortical. If foreign body seems infected would remove; otherwise advise large doses of bromides."

Roentgen Findings, April 16, 1919.—There is an oval-shaped bony defect about 3.5 cm. by 2 cm. in diameter, on the left side in the situation of the coronal suture, 1.5 cm. from the median line. The defect involves portions of both the anterior border of left parietal and posterior part of the squamous portion of left side of the frontal bone.

There is an irregular-shaped metal fragment, about 1½ x ¾ x ¾ cm. in diameter, situated 6.6 cm. vertically beneath the skin mark on the left side of the head, the patient lying on his right side with the head in a true lateral position. The surface marking corresponds to the anterior central portion of

the left parietal bone, being 1.2 cm. anterior and 7.8 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The metal fragment is below and slightly medial to the posterior part of the bony defect, being about 1 cm. from the mid-sagittal plane. The anatomical localization is in the para-central lobule of the left frontal lobe. Several distinct small bony sequestra are seen in the brain substance leading to the foreign body, and at least two sequestra are seen 2 cm. anterior to the same. The location

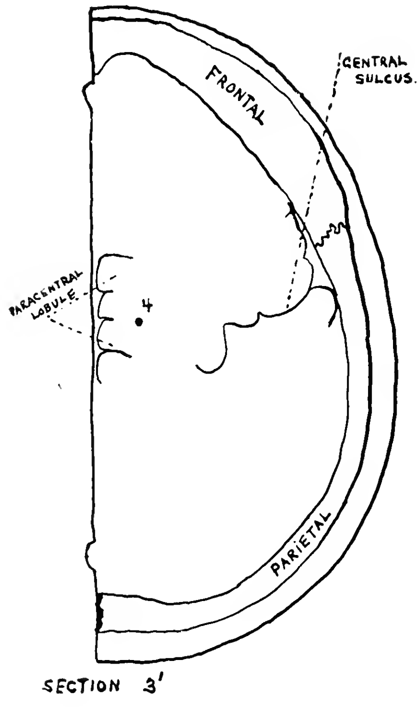

Figure 6.

of the metal fragment corresponds to Section 3′ of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 8.5 cm. from the posterior surface and 6.6 cm. from the lateral side. The patient's epilepsy continued to grow worse and another operation was decided upon. On May 6, 1919, the foreign body together with 6 small sequestra were removed, but the patient died three days later from an acute suppurative meningitis, following infection of the ventricles at the time of operation.

Case V. Admitted to hospital May 19, 1919, suffering from a gunshot wound of the head, having been transferred from Fort Des Moines.

White; age twenty; weight 145 pounds; farmer before entering the service. On September 17, 1918, he was shot in back of head and buttock while trying to escape from Fort Leavenworth. He was unconscious for ten days. Following this his right arm was paralyzed. There has been an almost continuous thumping sensation in the occipital region with occasional headaches.

Upon admission his general condition was good. There was a scar in the lower right occipital region, 2 cm. to the right of the median line on a plane with the foramen magnum. A disturbance of speech was present. The general physical examination was negative except for the following neurological findings:

Neurological Findings. — "Pupils equal, regular, and react normally, but a distinct nystagmus to left was present; exaggerated knee jerks; no Babinski or ankle clonus; some atrophy of the muscles of right forearm and shoulder girdle with weakness of hand; paresis right internal rectus; dysarthria, resembling scanning speech; tongue deviates slightly to left; marked intention tremor; no sensory or thermal changes. Epileptic episodes affecting all four extremities; sudden onset, weakness and vertigo without loss of consciousness, biting tongue or lips or passing urine in the spells. Diagnosis: Insular sclerosis syndrome (traumatic)."

Roentgen Findings, May 29, 1919.— There is an irregular-shaped metal fragment, about 1 x ½ x ¼ cm. in diameter, situated 5.2 cm. vertically beneath the skin mark on the right side of the head, the patient lying on his left side with head in a true lateral position. The surface marking corresponds to the posterior portion of the squamous part of the right temporal bone, being 3.5 cm. posterior and 1.25 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical location is in the

right superior semilunar lobule of the cerebellum, about 2 cm. from the median line. The location of the metal fragment corresponds to Section 9 of the Eycleshymer-Shoemaker *Cross Section Anatomy,* being 6.5 cm. from the posterior surface and 5.2 cm. from the lateral side.

There is also another irregular-shaped metal fragment about 1 x 1 x ¾ cm. in size in the muscular tissues immediately medial to the ramus of the mandible on the right side on a level with the atlas.

It is difficult to ascertain the point of entrance of the foreign body into the cranial cavity, as no bony defects are visible. There is a slight irregularity of the occipital bone on the right side about 2 cm. lateral to the foramen magnum which may be an old bone injury. In this situation some metallic dust is seen, which, however, forms a path to the foreign body in the situation of the right jaw. The only other explanation to account for the path of entrance of the foreign body into the cranial cavity would be through the foramen magnum, which is strongly suggestive.

Comment.—On April 27, 1920, this patient reported his general condition as fair. He suffers from frequent headaches and has had two severe attacks of Jacksonian convulsions in the past six months. There is some paresthesia on the right side and at times slight paresis.

Case VI. Admitted to hospital March 12, 1919, suffering from multiple gunshot wounds, having been transferred from overseas.

White; age twenty-eight; weight 150 pounds; occupation, steel construction worker before entering service. On November 1, 1918, he was hit by high explosive at Verdun. He received eleven wounds; three of head; five of right arm and shoulder; one of chest; one of each buttock and one of left ankle. Following the injury he was unconscious three weeks. The only previous history bearing on the case was that five years ago he was injured in a runaway accident and said his skull was fractured. Upon admission his general health was good, all the wounds being healed. There was a bony defect over right parietal bone about 2 cm. in diameter, and a scar was present over the right parietal region with some bony irregularity, also one in the left occipital region superiorly.

A healed wound 6 cm. long was present over the right inner arm extending over the brachial vessels to the pectoral muscles, one over the anterior part of head of humerus, lateral part of head, in posterior axillary region and edge of scapula. A wound also was present to the right of the fourth thoracic spine, there were multiple wounds of both buttocks and below left lateral malleolus; the only symptoms complained of were numbness of the outer part of the right arm and forearm.

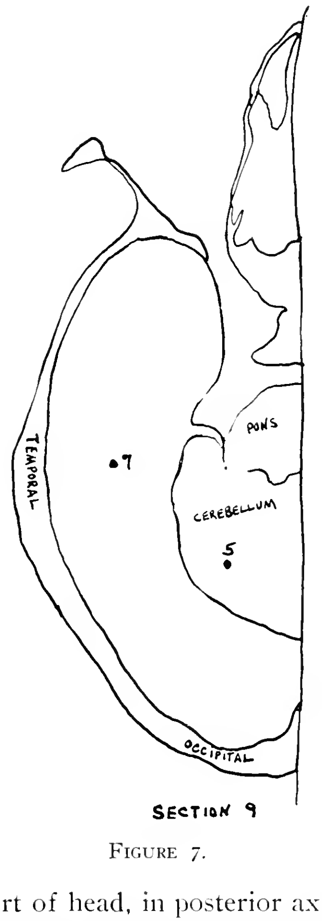

Figure 7.

Neurological Findings, April, 1919.—"The deep reflexes of the left side are increased more than upon the right. The reflexes of

the right lower extremity are greater than in the same arm. Cremasteric normal; abdominal reflexes diminished upon right side, especially in the upper segments. Slight incoordination in both legs and marked clumsiness in left arm. Slight astereognosis in left arm. No visual defect. Slight thickness of speech at times. Advise x-ray of spine over fourth dorsal. Can see no indication for cranial interference, but trouble may be remnant of old cord lesion."

The neurological findings on May 30, 1919, were: "Complete motor recovery. Stereognostic sense normal. Complete sensory recovery. Slight increase in deep reflexes."

Roentgen Findings, June 4, 1919.—There is a circular shaped bony defect, measuring 3 cm. in diameter, situated in the anterior-inferior portion of the parietal bone and anterior-superior portion of the squamous part of the temporal bone on the right side. Several small bony particles are present in the middle part of the defect. There is considerable irregularity of the antero-lateral portion of the squamous part of the frontal bone on the left side, suggesting a possible old bony injury. There is a circular-shaped old fracture line in the anterior-superior portion of the left parietal bone which extends into the frontal bone.

There is an irregular-shaped metal fragment, about ½ x ¼ x ¼ cm. in diameter, situated 2.7 cm. vertically beneath the skin mark on the left side of the head, the patient lying on his right side with the head in a true lateral position. The surface markings correspond to the central portion of the left parietal bone, being 4 cm. posterior and 9.75 cm. superior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical location of the above foreign body corresponds to the left inferior parietal lobule, being imbedded a little over 1 cm. within the brain substance. The location corresponds to Section 4 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 3.5 cm. from the posterior surface and 2.7 cm. from the lateral side.

A small metal fragment about 1 mm. in diameter is seen superficially in the skin or bone, posterior to the bony defect. Another very small fragment is imbedded in the brain substance in the path to the larger metal fragment. Three small fragments are also present in the right facial region.

Upon examination of the thoracic spine no injury was found, but a foreign body was present in the upper part of the right chest, which, however, was not localized.

Comments.—In a letter dated March 15, 1920, from the father of this patient, he

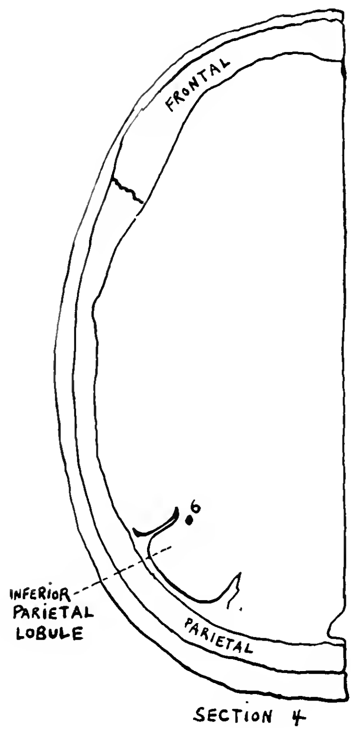

FIGURE 8.

stated that his son died on July 19, 1919, eight days after the foreign body was removed. Surgical removal was necessary due to Jacksonian epileptic attacks. This case is interesting in that the patient was discharged from the army a little over a month before the operation and gave no history of Jacksonian epilepsy and with a diagnosis of a "complete recovery."

CASE VII. Admitted to hospital, April 10,

1919, suffering from a gunshot wound of the head, having been transferred from over-seas.

White; age twenty-two; weight 165 pounds; occupation, farmer before entering the service. On July 22, 1919, he was hit by high explosive at Soissons. He remembers nothing about the accident. For a month following the accident he could not talk, had no paralysis except anesthesia over the affected side of the head and complete deafness in left ear. Later a bone transplant was placed in the skull to fill the defect but had to be removed on account of infection.

Upon admission his condition was good. There was a bony defect in the anterior lower parietal region. It measured about 2.5 cm. by 5 cm. Complete deafness in the left ear was present. There was soreness in the wound together with a discharging sinus.

Roentgen Findings, April 15, 1919.—There is an oval shaped bony defect, measuring about 4 x 5 cm. in diameter, situated in the posterior-inferior portion of the squamous portion of the frontal bone and the anterior-inferior part of the parietal bone on the left side. An irregular-shaped metal fragment about 1 ½ x 1 ¼ x ¾ cm. in diameter is situated in the cranial cavity, slightly superior and posterior to the left external meatus acusticus, which should be localized. No necrotic bone is in evidence.

Approximate location of foreign body without special localization methods: The metal fragment is about 3 cm. beneath the skin surface and is situated 1 cm. superior and posterior to the external meatus acusticus. The surface marking corresponds to the lower central part of the squamous portion of the left temporal bone. The anatomical localization is in the inferior temporal gyrus of the temporal lobe, the foreign body apparently resting on the posterior surface of the petrous portion of the temporal bone. The location would approximately correspond to Section 9 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being about 8.5 cm. from posterior surface and about 3 cm. from the lateral side.

Operation: Inasmuch as the foreign body was quite superficial it was decided to remove it. It was removed April 24, 1919. Unfortunately the patient developed an acute suppurative leptomeningitis and died four days later.

Case VIII. Admitted to hospital March 12, 1919, suffering from a gunshot wound of the head, having been transferred from over-seas.

White; age twenty-two, weight 155 pounds; occupation, farmer before entering service. On October 22, 1918, he was hit in the neck by a high explosive at the Argonne fight. He immediately became unconscious and was taken to a field hospital, where he was operated upon the following day. The operative report at that time states that the frontal bone was fractured, both frontal lobes of brain were damaged, no foreign body found, and that traumatized brain tissue and pieces of bone were removed. Following the initial trauma he suffered from paralysis of the entire right side except the face.

Upon admission his general condition was very good. There was a defect of about 5 cm. with 2 cm. of depression over the midfrontal region, which pulsated freely. A second scar was present over the posterior part of the parietal region. Complete right hemiplegia was present which is improving. There was fibrous ankylosis of the right elbow, permitting 10 per cent of motion. Healed sores were on the right heel and coccyx. Mentally he was acute.

Roentgen Findings, March 25, 1919.—There is a large irregular-shaped bony defect, measuring 5.5 x 5.75 cm. in diameter, involving the central part of the squamous portion of the frontal bone. It reaches almost as low as the frontal sinus and the greater part of the defect is to the left of the median line. There are several very small metal fragments in the left margin of the bony defect. There is a large gaping, irregular line extending across the squamous portion of the right temporal bone, into the posterior portion of the right parietal bone to the lambdoidal suture. It does not extend to the

bony defect anteriorly. It is difficult to imagine a skull fracture gaping to this degree and the patient living, yet there are no vessels that normally pursue this course which could produce erosion of bone in this situation.

There is an irregular-shaped metal fragment about 1½ x 1½ x ½ cm. in diameter situated 2.2 cm. vertically beneath the skin mark on the right side of the head, the patient lying on his left side with head in a true lateral position. The surface markings correspond to the inferior portion of the parietal bone nearly at the squamous suture line,

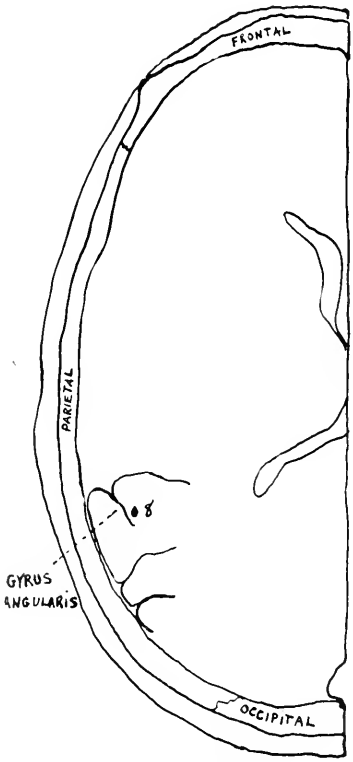

Figure 9.

being 5 cm. superior and 3.25 cm. posterior to the external meatus acusticus, Reid's base line being taken as a guide to these measurements. The anatomical location is in the superficial part of the right angular gyrus of the parietal lobe, being about 1 cm. within the brain substance. The location of the metal fragment corresponds to section 6 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, being 6 cm. from the posterior surface and 2.2 cm. from the lateral side.

Operative Findings.—As a result of the above roentgen findings, it was decided to remove the foreign body, inasmuch as it was quite superficial. On March 26th the skull was trephined over the localization mark, the dura split and the foreign body was removed, it being imbedded just beneath the cortex, as the localization findings recorded. The trephined bone was replaced and the patient made an uneventful recovery.

On April 17th a second operation was performed to repair the defect and depression in the frontal bone. A bone transplant from the left tibia was secured and again the patient made an uneventful recovery.

Neurological Findings, May 12, 1919.—Deep reflexes of the right side increased. Superficial reflexes as cremasteric and addominals diminished. No pathological reflexes. Slight weakness of the right side. Considerable slowness of movements of that side and some clumsiness. No sensory disturbances, no astereognosis. Cranial nerves normal, visual fields normal, discs normal. Some intentional hypertonia of arm when flexing or extending the extremity. No mental disturbance.

The patient continued to improve and when last seen, in August, the only symptom complained of was still some paresis of the right arm.

Comments.—The interesting point in this case is the extreme trauma received by the frontal lobes, and yet apparently no symptoms emanating from this destruction.

In a letter received March 13, 1920, the patient states that his general health is fairly good, although at times he is very nervous and has vertigo. There is some parasthesia in the left leg most of the time, but he has had no Jacksonian attacks.

Case IX. Admitted to hospital April 4, 1919, suffering from gunshot wounds of head, right shoulder and arm, having been transferred from over-seas.

White; age twenty-six; weight 175 pounds; occupation, farmer before entering

the service. On November 4, 1918, he received multiple gunshot wounds (presumably from high explosive) at Verdun. Following this his left arm became paralyzed but has since recovered.

Upon admission his general condition was excellent. There was an irregular scar present in the right parietal region with slight depression of the bone. Several scars were present in the right shoulder and arm. The physical examination otherwise was negative and no symptoms were complained of.

Roentgen Findings, April 16, 1919.—There is some irregularity of the antero-superior part of the right parietal bone, which is suggestive of an old fracture, there being a loss of bone substance, but a complete bony defect is not present. Several small metal fragments are present in the situation of the fracture and should be localized.

Approximate location of foreign body without special localization methods. The metal fragment is about 2 x 2 x 1 mm. in diameter and approximately 2.5 cm. beneath the skin surface. The surface markings correspond to the posterior-superior part of the squamous portion of the frontal bone on the right side, and the anatomical location is in the superficial part of the medial frontal gyrus. The location would approximately correspond to Section 3 of the Eycleshymer-Shoemaker *Cross Section Anatomy*, but exact position cannot be stated, as definite localization was not made. An examination of the right arm showed no bony lesion, but several small metal fragments were scattered in the soft tissues. The soldier was discharged May 5, 1919, apparently recovered.

Comments.—In a letter dated March 17, 1920, this patient stated that his general health was fairly good but that he was troubled with headaches and at times has vertigo. There was some numbness in the left hand, and since his discharge he had had two Jacksonian attacks.

Case X. Admitted to hospital March 2, 1919, suffering from a gunshot wound of the head, having been transferred from overseas.

White; Russian; age twenty-seven; occupation, molder before entering the service. On November 6, 1918, in the Argonne fight he received a gunshot wound of the head. On November 23, 1918, he was operated upon.

Upon admission his general condition was good. There was a healed scar with depression over the occipital bone. The physical examination was otherwise negative and no symptoms were complained of.

Roentgen Findings, June 12, 1920.—There is an irregular-shaped bony defect measuring about 6 x 4.5 cm. in diameter in the situation of the lambda, the greater portion being on the right side. It involves both parietals and the occipital bone. A small metal fragment about 1 mm. in diameter is seen in a plane immediately posterior to the superior part of the dorsum sella and should be localized. Due to the fact that a good postero-anterior plate was not obtained, the approximate lateral depth cannot be stated. The patient was discharged May 5, 1919, apparently normal in every way.

Comments.—On April 5, 1920, this patient reported his general health as fair and that he had occasional headaches and vertigo. He also complained of paresthesia at times on the left side, but had had no Jacksonian attacks.

Case XI. Admitted to hospital June 25, 1919, suffering from gunshot wounds of head and left arm and a simple fracture of the left leg, having been transferred from over-seas.

White; age twenty-seven; weight 185 pounds; occupation, bridge carpenter before entering the service. On July 4, 1918, on the Alsace front was hit in the skull and arm by shrapnel.

Upon admission his general condition was good; a scar with some depression in the occiput was noted and also a penetrating wound of the left arm which was healed. The physical findings were otherwise negative but the soldier complained of occipital headaches and also slight deafness.

Roentgen Findings, June 27, 1919.—There was a bony defect in the left half of the occipital bone, including the posterior border of the left parietal. It measures about 2 cm. in diameter and the edges are smooth and regular. A metal fragment about 5 cm. in diameter is lying in the posterior fossa about 3 cm. to the left of the median line. A smaller fragment is present just lateral to the above.

Unfortunately the above foreign bodies were not localized.

Comments.—On March 14, 1920, this patient reported his general health as very poor. He suffers from headaches and twice monthly has Jacksonian attacks. He also complains of some paresthesia in his hands.

CONCLUSION

Three of the eleven cases have died. Four of the cases have been operated upon and the foreign bodies removed. Three died on the 3rd, 4th and 8th days respectively following the operation, as a result of meningitis, making an operative mortality of 75 per cent.

Of the eight living cases, seven still have foreign bodies in the brain and five of these have Jacksonian epileptic attacks. Of the two who are not so affected, one complains of great pains in his head at times and in the other case the foreign body is extremely small in size—the smallest in the series. Inasmuch as the first Jacksonian convulsion did not occur in one of the cases until fifteen months after the injury, these men may yet develop this condition, as it has been but sixteen and nineteen months respectively since they were injured. The one patient who lived following the removal of the foreign body has had no convulsions. All the cases except one complain of headaches or vertigo, usually the latter. About half of the cases have paresthesia at times in the formerly paralyzed parts, although the paralysis itself has disappeared in most of the cases. The general health of most of the patients is fairly good.

In no case does the foreign body appear to be causing any special symptom or symptoms because of its particular anatomical location. In other words, as far as we are able to ascertain, the function of that portion of the brain in which the foreign body is located is not disturbed as a result of its presence. The symptoms complained of are in general those which practically all such patients have. The special symptoms are due to the traumatized portion of the brain through which the foreign body has passed to reach its final resting place. In some cases, depending upon the composition of the foreign body, fine metallic dust can be traced from the point of entrance into the skull to the foreign body. It might also be interesting to note that in all the cases reported, except two, the men stated that as far as they recalled, they had their helmets on at the time of injury and that the foreign body evidently passed through them.

It appears to me, in view of the very large percentage of cases developing Jacksonian attacks, that every former soldier in our army who received a foreign body in his brain during the past war should be given liberal compensation. There is no certainty what may happen to the foreign body or what symptoms may develop. A man who may have a Jacksonian convulsion at any time is greatly handicapped in the pursuit of many occupations. The high operative mortality forbids surgical approach to remove the foreign body, especially if it be deeply situated. That many medical officers in our army did not appreciate the seriousness of foreign bodies in the brain is evident by the small percentage of disability that was recommended by the S. C. D. Boards for some of these men when they were discharged. I know of one case where 20 per cent was recommended and in another 25 per cent. One of these cases is now having monthly Jacksonian attacks. This is certainly a serious injustice to men who have suffered from one of the most severe injuries they can receive and yet live and who are likely to suffer and be handicapped for the rest of their lives as a result.

A MONOMETER AND FLOW-VOLUMETER FOR TRANSUTERINE PERITONEL INFLATION TO DETERMINE PATENCY OF FALLOPIAN TUBES IN CASES OF STERILITY

By I. C. RUBIN, M.D., F.A.C.S.

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NEW YORK CITY

THE present apparatus enables us to measure the quantity and the flow of oxygen or carbon dioxide gas used in insufflating the uterus to test the Fallopian tubes for patency. A manometer of the "tycos" or mercury type is combined with it, allowing for pressure reading at the same time as the gas flows. It does away with the necessity of first displacing water from another vessel at a certain rate of flow to estimate the volume of gas. This at best was only an approximate estimation.

In this apparatus the pulsating type of water displacement meter is used. It is adapted from the well-known chlorine control apparatus employed by the firm of Wallace & Tiernan for water purification by the process of chlorination.[1] The meter is of glass and is therefore non-corrodible and consists of an inverted glass siphon within a cylindrical glass meter. The latter is calibrated to a given capacity, as a rule 40 c.c. (Fig. 1.) It is hydraulic in principle, scientific, accurate and dependable. The upper end of the glass cylinder is attenuated to a narrow tube to which rubber tubing is attached to convey the gas from its source. The lower end dips down into the water contained in the large glass tube or jar of convenient size. (Fig. 2.) This glass tube or jar is provided with a rubber stopper perforated at three points, through one of which the narrow end of the volumeter passes. Two separate glass tubes pass each into the container to just below the lower limit of the stopper (Fig. 2). To one of these the pressure gauge is attached and to the other a piece of rubber tubing for the outlet of the gas. To this piece of rubber tubing the intra-uterine cannula is attached. A spring relief valve may be provided which works automatically, or in lieu of this a needle valve is placed in the course of the outlet tubing. I have found this latter to be effective and easy to handle. The spring valve is regulated to blow off at a pressure of

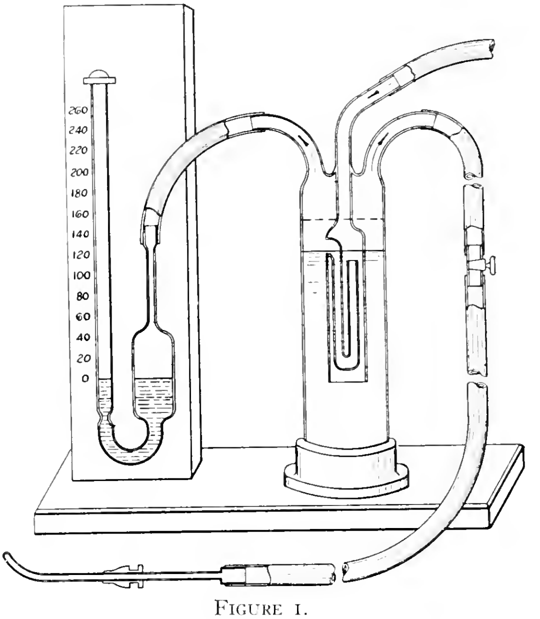


FIGURE 1.

250 millimeters of mercury. While this can be dispensed with it is an aid and is well combined with the needle valve relief. Figure 2 represents the apparatus as assembled from the parts as described. For the convenience of those who do not care to take the trouble of doing this I have had the siphon meter and glass jar with outlet and inlet connections blown in one piece and attached to a mercurial manometer. (Fig. 3.)

[1] I am indebted to Messrs. Wallace & Tiernan for the courtesy of the use of their volumeter in my work.

The operation of the siphon meter is as follows: View X shows the water level 2 in the meter at the beginning of the pulsation, and view Y shows the water level 2 just before the siphon C-G breaks at D, which completes one pulsation of the meter. When the downward flowing gas in A reaches the to a rise of 100 millimeters within 15 seconds. This can be determined readily by pinching the outlet tubing as the flow is regulated till it causes a rise of pressure to 100 mm. mercury in 15 seconds time. A ratio of 10 seconds to 100 mm. will also be satisfactory; but in the non-patent Fallopian tubes,

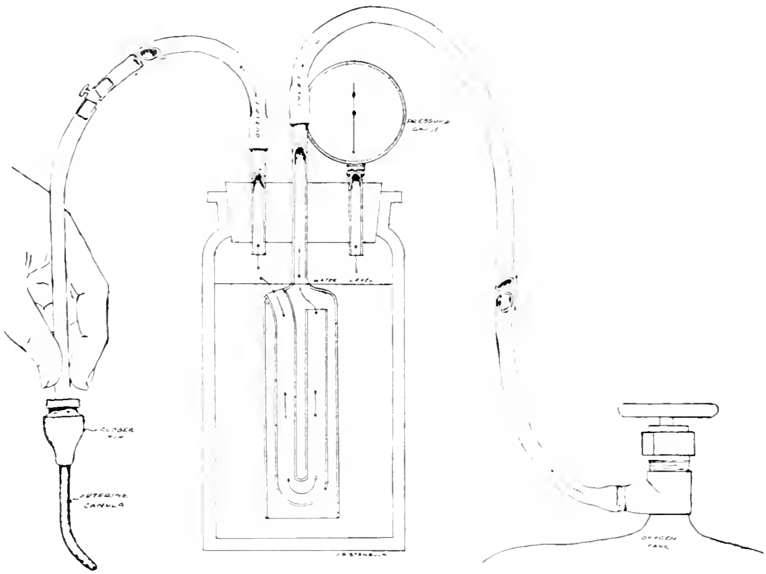


FIGURE 2.

point D, it will rush up through the tube G of the syphon, and the bell or compartment B will refill with water up to the upper end of C. This completes one pulsation or measure of the meter, and the amount of gas delivered by this one pulsation is, of course, the capacity of the compartment B between the points F and D. The siphon meter used in my work has a capacity of 40 c.c. The amount of gas flowing may be determined by counting the number of pulsations of the meter per minute.

For the purpose of determining the patency of the Fallopian tubes four pulsations delivering 160 c.c. of gas are all that are required. In thin individuals from two to three pulsations will suffice to produce in the patent cases the subphrenic pneumoperitoneum which will be clearly seen with the fluoroscope. The pressure reading is of considerable importance, and I have found that the rate of flow is best regulated previous where the matter of pressure is of somewhat greater importance than in the case of patency, it is better to have the slower rate of flow, i.e., the 15 seconds to 100 mm. mercury. With this rate established (and this is done in a few seconds) the gas is allowed to pass through the volumeter and thence through the outlet tubing and cannula into the uterus. The needle valve is released until the cannula is inserted well into the uterine cavity beyond the internal os when it should be shut, making the system air-tight. Almost instantly the pressure rises at the rate predetermined and will vary somewhat in cases of patency. The pressure required to overcome the resistance of the uterus and tubes where there is no tubal obstruction to the free passage of the gas will vary between 40 and 100 mm. When reaching these points it will fall sharply or slowly or even fluctuate about them. Occasionally the initial rise of pressure in the patent tubes will be higher,

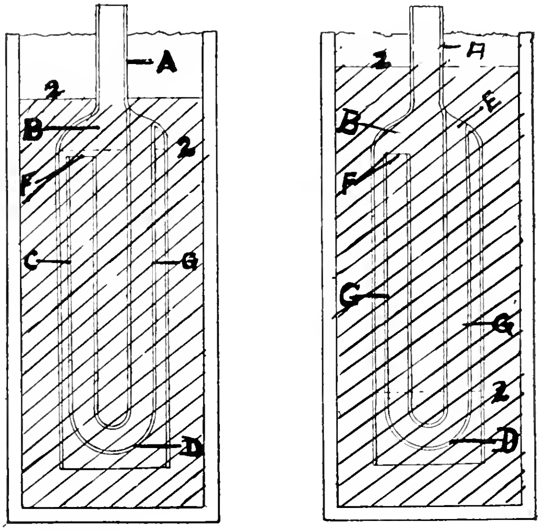
reaching 160 before it drops. The significance of this will be taken up in another communication.

In the non-patent tubes the pressure rises steadily to a point well beyond 200. It is not necessary to carry this beyond 250 mm., because in all the cases so far examined this pressure was found to indicate occlusion. When, as occasionally happens, the gas will go through after reaching a pressure of 200 mm. mercury, that case may for practical purposes be considered sterile, because the obstruction is nearly complete. But it must be borne constantly in mind that the rate of flow must not exceed in rapidity that of 100 mm. in 15 seconds. I have used a slower rate of flow in many cases, particularly in the non-patent cases where it is desirable to check up the finding of the first examination. This can be done during the same sitting when the flow is retarded, so that it requires 20 to 30 seconds to raise the mercury column to 100 millimeters.

While the apparatus has been assembled for the transuterine peritoneal inflation to determine the patiency of Fallopian tubes in cases of sterility, it may be used to advantage in the direct transperitoneal inflation by abdominal puncture. The pressure gauge is in the latter case not so important, but it provides an accurate volumetric measure of the gas introduced into the peritoneal cavity. The flow being visible through the volumeter it may be stopped at any point when a desired amount has been given. The number of pulsations would have to be increased to say, 12 times 40 c.c. or 25 times 40 c.c., depending upon the amount of gas that one desires to introduce into the peritoneal cavity.

Thus far the apparatus has been used in 225 cases out of a total of 350 insufflations and has given complete satisfaction.

I am glad to acknowledge my indebtedness to Dr. Reuben Peterson for many valuable suggestions in developing the finer details of the technique and in checking up my work. He has had the happy thought of combining the transuterine with the transperitoneal methods of producing artificial pneumoperitoneum, and in his hands the method has become established as a valuable adjunct in gynecological diagnosis.



X Y

Figure 3.

MULTIPLE OSTEOCHONDROMATA*

By BERNARD PIERRE WIDMANN, M.D.

PHILADELPHIA, PENNSYLVANIA

If we were to stop after a careful review of the scant American literature on multiple cartilaginous exostosis, we should probably conclude that the condition is obscure and rare.

Ehrenfried[1] in 1916 contributed a most complete and detailed review of this subject, comprising a study of reported cases largely from the English literature, in which he demonstrates clearly that the condition is not rare, but a rather common occurrence.

Whether it is considered unimportant, or common, or obscure, every case presents some unusual or striking characteristic, either as to history, skeletal deformity, or concomitant sequelae. This should stimulate interest and study of these unusual phenomena as to their nature, extent, and frequency of occurrence, and they should be of particular interest from a roentgenological point of view. There has been no common accepted standard of terminology. Virchow established the name of Multiple Cartilaginous Exostoses. Hereditary Deforming Chondroplasia, Multiple Cartilaginous Exostoses, Ossified Diathesis, Multiple Cancellous Exostoses, Rachitiform Enchondrosis, Chondral Dysplasia, and Multiple Congenital Osteochondromata, are names that have been applied to this condition. It is a definite pathologic entity due to an anomoly in ossification of temporary cartilage. There is as yet considerable variance of opinion as to its etiology. Ehrenfried characterizes the conditions as the occurrence of multiple, more or less symmetrical cartilaginous and osteocartilaginous growths, within and on the the skeletal system, generally benign and resulting from a disturbance in the proliferation of the bone-forming cartilage.

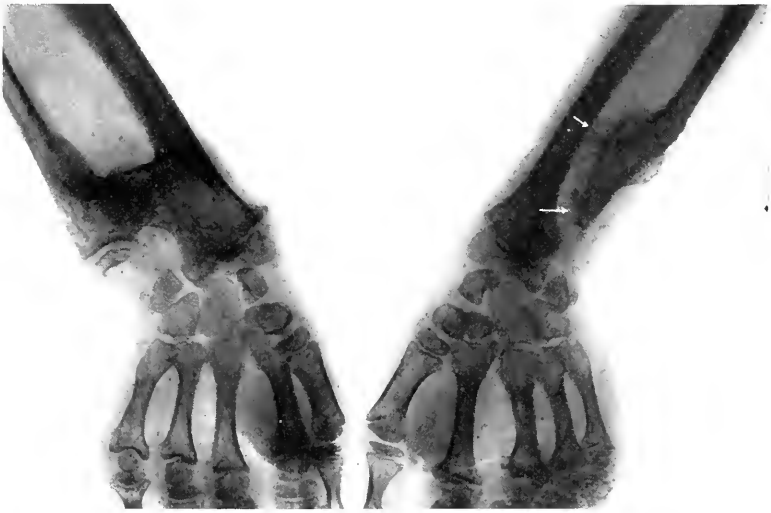


Fig. 1. True bony union between lower ends of radius and ulna. Thickened and shortened lower end of ulna.

Percy[2] investigated 113 descendants of a case, of whom 26 were affected, 73 not affected, and 14 unknown. Of those affected 22 were males and 4 females. Transmission through affected males and females was about in relative proportion of those affec-

*Thesis presented with application for membership in The American Roentgen Ray Society.

ted, but in two cases the disease was transmitted through unaffected females. Familial cases have been reported by Gibbony,[3] Oberndorf,[4] Boggs,[5] Oehsner and Rothstein,[6] and Ashhurst.[7]

Endocrine derangements, trophic disturbances depending on disease of the central nervous system, the theory of infection because of the fever and rheumatic pains in a few reported cases, are theories that have been advanced from different sources as possible causes of multiple osteochondromata. Pissovy found tuberculosis in forty of one hundred cases. This association may be significant. Hunter emphasized its constitutional nature. Volkmann and others have assigned rickets as the cause. Paget recognized it as an ossific diathesis due to some morbid condition of the blood. Several German writers have recognized it as a disturbance of growth. Keith, at a meeting of the Medical Society of London, January, 1920, insists that the disease be removed from the category of tumors and classified among the disorders of growth under the name suggested by Morley Roberts — "diaphyseal aclasis."

If John Hunter's teaching of bone growth be correct, i.e., that new bone is laid at the extremities of the shaft in the diaphyseal lines in the first process, and that in the second process which Hunter named the "modeling process," the cancellous bone laid down is rebuilt, trimmed and gradually converted into an architectural part of the shaft, then in diaphyseal aclasis, Keith concluded, the "modeling process" is arrested; hence between the properly formed part of the shaft and the epipyhseal end there is interpolated an irregular cylinder of imperfectly modeled bone on the surface of which there are several outgrowths. The disturbance is greatest where the growth is most vigorous and prolonged.

In the following case no hereditary history was obtainable beyond the immediate family. Master H. C. White (thirteen) was referred to the Neurological Department of the Polyclinic Hospital to discover if possible the

FIG. 2. Dislocation probably due to overgrowth of head of radius.

cause and cure of the multiple body tumors.

Chief Complaints. Prominences and deformities about wrists, knees, ankles, scapulae and clavicles.

Family History. Mother living and well at fifty-two. Father living and well at fifty-seven. Five brothers and two sisters all living and in good health.

Previous History. Youngest child, no history of tuberculosis. No cardiac renal disease nor any chronic diathesis; normal birth; adenoids in childhood. Bony tumors about joints first noticed about the age of four.

Fig. 3. Shortening of tibia.

Present History. Bony prominences about both wrists, ankles, knees, scapulae and clavicles. No pain or discomfort of any kind. No soreness, no tenderness, no evidence of inflammation.

Physical Examination. Height 4 feet 8 inches, weight 82 pounds. Patient a cheerful, alert, intelligent-looking boy. Long loose extremities, good free and easy function of all joints. Hyperextention of 10 to 15 degrees at elbows. Upper extremities seem slightly shorter than normal. Moderate hypophysis, prominent bony enlargements at wrists, knees, and ankle joints, over the clavicles and inferior angle of left scapulae. No apparent enlargement of the thyroid. Von Gräfe's and Stellwag's signs present. Tonsils enlarged and the cheesy material exuded. Wide area between uvula and post-pharyngeal wall suggested adenoids. Aortic second sound increased over other sounds of heart.

Blood pressure: Systolic 100, Diastolic 60. Urine, negative. Wasserman negative. Von Pirquet, negative.

The roentgenographic findings in this case are very interesting. In general there is a disturbance in the ends of all the diaphyses of the long bones. This involves even the ribs. None of them are absolutely normal. The disturbance varies from a slight thickening to actual tumor formation 1½ inches in thickness. All of these tumors have the characteristics of bone; that is, they consist of cancellous tissue, more or less regularly arranged, with no destructive effects, and none of the appearances that occur in true tumors. The lower extremity of the right humerus is shortened, thickened to twice its normal diameter and is associated with a number of separate nodules. In the left wrist the exostoses extend between the lower extremity of the radius and ulna, and are apparently united with a true bony union. Even the left ulna is considerably shortened in comparison with the radius, probably due to an interference with the normal growth of the diaphysis in this bone. In the right elbow there is apparently shortening of the ulna with considerable thickening of the upper extremity of the ulna and comparative overgrowth in length of the radius, which gives a dislocation. At the lower extremity of the tibia and fibula of both legs there may be shortening of the tibia and corresponding elongation of the fibula, probably due to this overgrowth. There are exostoses also about the diaphysis of the os calcis.

The following three cases were taken from

Dr. Pfahler's records and the examinations were made on January 27, 1903, at the request of Dr. J. Hendris Lloyd: the father, T. O'B., age forty-two; the son, J. O'B., age ten, and the daughter, E. O'B., age thirteen. There were no other children. All of these three cases were examined and all of the long bones of the bodies, including the ribs,

FIG. 4. Elongation of fibula.

showed exostoses growing from the ends of the diaphyses.

There is nothing in this report that distinguishes these cases as unusual in type and skeletal deformity from those on record. The deduction must follow, however, that the condition must be classed as a distinct abnormal pathological entity. A study of the characteristic finding is fascinating and the roentgenologists should ferret out their records and classify any data from their histories and physical examinations that may possibly serve as a working basis in determining the etiological factors and possible methods of treatment. While these bony growths are benign they may become malignant. Several unusual anomalies have been recorded. Oschner and Rothstein [6] report a case of multiple exostosis with an intraspinal endostosis pressing on the spinal cord causing incoordination of the upper and lower extremities with improvement after surgical intervention. Clark and Atwood found an exostosis growing from the sella turcica in a case of multiple exostosis causing pressure in the pituitary body.

Oberdorf[4] observed a boy of nineteen who presented a typical clinical picture of acromegaly.

It would seem, therefore, that this is undoubtedly a constitutional disease. It has to do with the growth in length of the long bones and must involve a disease of the organs controlling such growth, and would seem, therefore, to be primarily a disease of the endochrine system. There is certainly a hereditary tendency in some instances.

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SUPER-RADIATION AND DELAYED REACTIONS*

By ALBERT SOILAND, M.D., F.A.C.S.

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FOR want of a more suitable term, the writer will designate the new roentgen ray deep therapy method as super-radiation. The potentiality of this highly specialized form of deeply penetrating ray energy is of more than ordinary interest. To you who have followed the life history of our specialty and have had an intimate and personal share in its development, the importance of super-radiation to medicine is immediately apparent. To you, too, its many difficulties are not unknown. There are many, however, who will perhaps not readily grasp the fact that the path to this fascinating new therapeutic field is beset by many dangers, and that he who travels its course must assume grave responsibilities. It is not my intention to discourage investigation. Rather I am filled with enthusiasm by the knowledge that we are on the verge of obtaining from the *x*-ray tube, gamma radiation in unlimited amount. Realizing it, we must approach this work with consummate care, and in our desire to make progress, make haste slowly. The necessity for this care is obvious, and need not be emphasized before you, except to call your attention to its urgency.

The fact that very soon electrical transformers with a capacity of 200 kilovolts will be available and that tubes to carry this stress successfully are now being made, is of the greatest possible interest to us. We must prepare ourselves to make proper use of this apparatus, which should not be a severe task if we profit by the lessons of the past.

Consider, first, that you are increasing your voltage 100 per cent and what that implies with your present equipment and what you now consider safe protection to yourself and your patient from the high tension line. Second, the probabilities are that even with your present lead-covered operating booth and lead-glass-covered tube holder, you are none too well protected. What, then, will you require for protection against such super-radiation as is here indicated? Third, and of greater importance, what of the primary and secondary reaction of prolonged gamma radiation upon your patient?

To solve the first problem presented, no doubt manufacturers will see that whenever possible only non-conducting materials will enter into the appliances produced. Then the radiologist should personally superintend the installation and assure himself that all air-gaps between electrical points anywhere in the room exceed by at least one-third distance the capacity air-gap between the sparking points of the transformer. To fulfil this requirement will necessitate at least one half more space than that occupied by the average treatment installation of to-day. Again, the patient's table, the tube stand, and all parts of the apparatus which carry the high line should be of wood or similar non-conducting material, and no metal of any description should come in contact with the patient. An efficient automatic and fool-proof circuit breaker should also be in the line.

These provisions, with the line switch brought into proper position and correctly wired, should insure a reasonably safe installation against accumulated high potential discharges.

Turning to the protection of the operator, I do not hesitate to emphasize an often repeated statement that the average roentgenologist is practically unprotected from the secondary *x*-radiation, and only very slightly protected from the primary *x*-radiation. I have seen men all over America working with 90 kilovolt tube discharges, and the only shield between them and the functionating tube, 4 feet of air space and a single

*Chairman's Address to the Second Annual Meeting of the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY, at Portland, Ore., May 27, 1921.

4 by 6 foot panel, containing a small sheet of lead-glass for a window, and 1/32 inch thick lead over the rest of the panel. With the advent of the forthcoming super-machine, a law should be passed which will compel every radiologist thoroughly to protect himself, his operator, and his patient by every known means against present and future *x*-ray dangers. It should be determined by competent electrical research just how much lead and distance screening is necessary for complete protection, and then every institution should be equipped in conformity with the specifications laid down.

We will now approach the third and most important problem. The patient's status with respect to immediate protection against primary as well as the problem of delayed secondary reactions must be most carefully considered. Immediate protection, as referred to in the preceding sentence, is limited to primary and secondary radiation from the tube itself, as it may reach any part of the body, not necessarily in the field of treatment. The ordinary lead-glass cover bowl as used to-day is not sufficient, but this can be covered by lead-rubber composition cloth sufficiently heavy to serve the purpose adequately. Protection from the secondary direct radiation into the treatment field is an entirely different matter, and one which we cannot so readily control. It is to this I call your most respectful attention, as here we shall have to deal with the very unpleasant phenomenon which not infrequently follows, known as a delayed roentgen reaction. We have met with unfortunate results, some of us more frequently than others, in obtaining unexpected *x*-ray reactions from the mild to the gangrenous varieties, even in cases where all the provisions in conformity with our supposed table of safe dosage had been carried out. Such unfortunate reactions have been observed appearing as late as three years from the date of the last *x*-ray treatment, and giving no sign of their insidious approach in the interval. This is not theory, but a stubborn fact, for I have personally seen several cases in which two or three years after radiation for uterine conditions, the abdomen has taken on gangrenous changes, too extensive for surgery and uninfluenced by any treatment. You know the result.

Are we to assume, then, that with the inauguration of super-radiation the dangers from delayed radiation will be increased twofold? As has been already pointed out in a previous paragraph, the dangers from secondary tube radiation or secondary rays originating within the tube proper are increased, but it is by no means certain that this rule holds good in the secondary ray phenomena following direct radiation upon and within the human body, when this is administered through metallic filters of great density, admitting only a homogeneous gamma radiation. It must be firmly fixed in mind that we are now considering radiation which up to the present time has been available only in small amount, and whose remote effect, consequently, sufficient time has not yet elapsed to determine. It would appear to the writer that, inasmuch as untoward *x*-ray reactions occasionally follow even the most careful *x*-ray technique, super-radiation will in all probability increase in proportion to its greater volume whatever sequelae may be induced by this enormous increase of radiation units. On the other hand, we may well conclude that with voltages of 200 kilovolts and plus, no alpha or beta ray effects need be seriously considered, nor is gamma radiation *per se* a source of danger to cell life, but only when releasing its energy of radiation under prolonged exposures does it become a serious problem. The effects of super-radiation, therefore, are as yet only partially visualized.

We are all familiar with the distressing immediate effects of a massive dose, beginning with nausea, then vomiting, shock, and prostration, the severity of which varies in proportion to the length of time the rays are applied and the particular radio-sensitiveness of the patient. The question we may well ask now is what future metabolic or destructive changes are to be anticipated where a definite area of the human body has been invaded by eight to ten hours of super-radiation? The comparatively brief time — two years — in

which such exposures have been maintained, is, in the writer's opinion, far too short to determine end-results, either curative or pathological. With the knowledge before us that greater time is necessary to ascertain delayed pathological reactions even in the ordinary technique of to-day, would it not be wise to desist for the time being from this heroic method and adopt a safe middle ground position, until we have been able to study late cases and collect sufficient data for tabulation? In the meantime, let us enter firmly but cautiously our new battlefields, with the fervent hope that we shall succeed in mastering this potent force without the necessity for the humiliating admission later that we have, peradventure, been instrumental in producing an end-result far more terrible in its consequences than the dreadful disease we are attempting to conquer.

ROENTGEN RAY TREATMENT OF ACNE VULGARIS*

By. J. M. MARTIN, M.D., AND CHAS. L. MARTIN, M.D.

DALLAS, TEXAS

ACNE vulgaris is a very general disease and appears in all parts of the country and among all classes of people. It is pretty equally divided between the sexes and is most common from the age of thirteen to that of thirty-seven. A good many thus afflicted do not apply to physicians for treatment, but content themselves with the use of patent medicines, soaps and creams. A large number of girls in the cities frequent the beauty parlors where steaming, massage, comedo extractors, violet rays, and ointments are freely used. Others apply to their family physicians who advise diets, mineral waters, laxatives, various kinds of ointments and washes. To the latter the dermatologist usually adds the curette, the lancet, vaccines, the Kromayer lamp and in some cases *x*-rays.

Under the simplest treatment most cases appear to improve for a time, only to relapse. Some appear to run a definite course and undergo complete resolution, as though the disease were self-limited. A considerable number of these cases, after going the rounds for several years without relief, finally in desperation come to the roentgenologist as a last resort.

It has often been argued that radiotherapy is a more or less dangerous agent and should not be employed except in severe types of acne. The comedo and pustular stages of the less severe types are unsightly and are especially objectionable to women who wish to keep their skin free from the scars and lifelong disfigurement that result from pitting and cicatricial contraction in the skin not unlike the scars from smallpox. We feel that such types should receive the benefits of irradiation early in the disease.

In this connection it cannot be denied that all or nearly all potent therapeutic measures are dangerous in unskilled hands, and the *x*-ray is no exception to this rule. Accidents and unfavorable reactions resulting from treatment given during the evolution of a system of accurate roentgen therapy should not prejudice the physician against the use of so valuable a curative agent.

The etiology of acne has for years been a moot question. In an editorial in the *Medical Record* in 1896 it is stated that "acne is an inflammation of the sebaceous glands and adjacent tissue." The causes are divided into the three following classes: (1) The over-production of sebum; (2) impediments to the escape of sebum, and (3) irritation of the glands by foreign matters, such as pyogenic organisms from the outside or drugs eliminated through the glands. The same writer quotes Dr. R. A. McDonnell[1] as saying that "the causative factors of acne may be increased to eighteen or twenty," from which the writer draws the conclusion that "acne may be produced by almost any-

*Read at the Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

thing from indigestion to a state of exalted self-consciousness." Recent authors have added little.

Acne is characterized by several stages of development rather than by distinct types. The papules may remain as such for a considerable time and then undergo resolution, or they may increase in size until they become tubercles, or suppuration may take place within the sebaceous glands and the hair follicles, thereby producing pustules. Healing of the pustules produces atrophic scars, pitting, and cicatricial tissue in the skin.

Most investigators believe that the earlier lesions, that is, the small papules, result from the infiltration of plasma cells, giant cells, mast cells and fusiform cells about the outlets of the sebaceous glands. As the infiltration continues and the entire gland and later the hair follicle are surrounded by the infiltrating cells a large papule and finally a tubercle is formed. At times several glands and follicles may be involved in one lesion. When suppuration sets in leukocytes appear and the glandular structure is destroyed. In some cases the destructive process also involves the hair follicles and small dermic abscesses may be formed. Semon,[2] in a recent article, mentions the fact that periglandular fibrosis occurs which is often exceedingly dense. He feels that this fibrosis protects bacteria lying within the glands from the action of vaccines.

FIG. 1. A portion of normal skin from the abdomen of a guinea pig showing a hair follicle to which is attached a sebaceous gland high up on the right side as indicated by the arrow. The sebaceous glands in this region are all small.

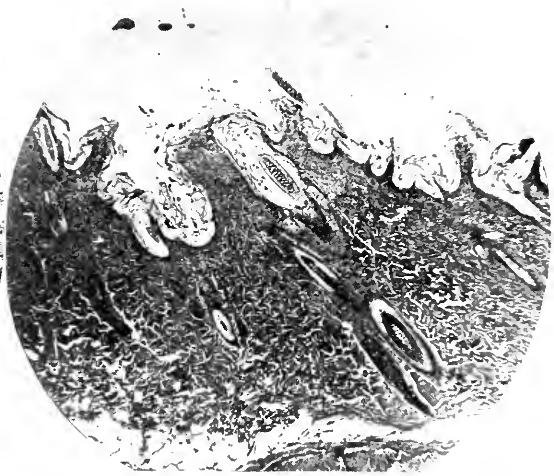

FIG. 2. A portion of skin removed from the abdomen of a guinea pig two days after the administration of an erythema dose of x-rays to this region. The arrows indicate sebaceous glands which have a normal histological appearance.

The diagnosis of acne should not be difficult. The affection most likely to simulate acne is acnitis which has been called "Disseminated Follicular Lupus," "Acne Rodens," "Acne Necrotica," etc. Ketron[3] in an excellent article has pointed out the following points characteristic of acnitis as distinguished from acne: (1) Its resemblance in color and general aspect to lupus tissue: (2) its indolent and non-inflammatory course; (3) its unsusceptibility to ordinary acne therapy. From a careful histologic study of tissue affected with acnitis, Ketron[3] thought he had located the beginning lesions. Nodules of infiltrating cells lay in the lower half of the cutis and were in no way connected with the sweat glands, hair follicles or sebaceous glands, but lay along the blood-vessels. Ketron[3] believed that the primary lesions of acnitis originate in the small blood-vessels at various depths in the cutis.

In reviewing the literature on the roentgen treatment of acne we were surprised to find as far back as 1896 rather detailed reports of cases that were successfully treated. In spite of the fact that a good many ugly x-ray burns occurred during the early days of roentgen therapy, many roentgenologists persevered in their efforts and obtained surprisingly good results. Viewing the rise of roentgen therapy in the light of our present knowledge, we are forcibly reminded that "fools rush in where angels fear to tread." Following along untrodden paths, without accurate means of dose determination, the wonder is that accidents were so rare.

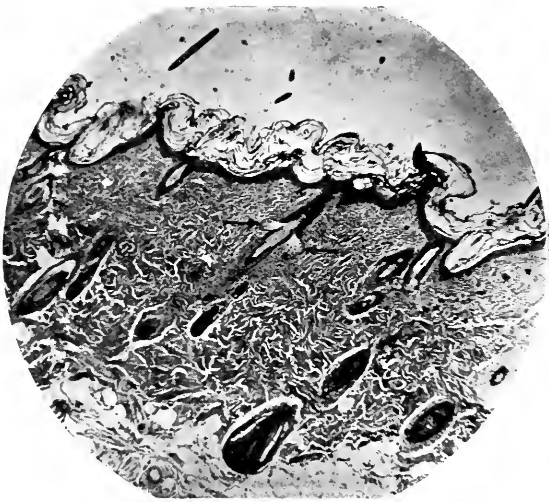

FIG. 3. Skin removed four days after exposure. In the following illustrations, the arrows indicate the location of the sebaceous glands.

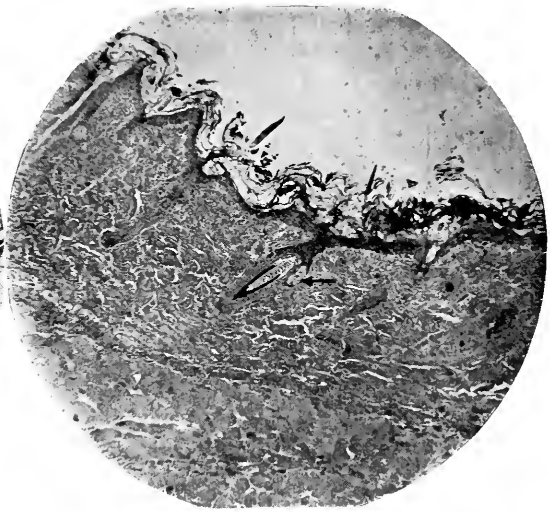

FIG. 4. Skin removed six days after exposure.

In 1896 Ullman[4] reported the cure of a case of acne treated by x-rays. In 1898 Gautier[5] treated three cases that resulted favorably after other methods had failed. In 1900 Schiff[6] and Freund of Vienna used rather heroic doses of x-rays in the treatment of acne, with gratifying results. In 1902 R. R. Campbell[7] reported fifteen cases of acne treated by roentgen therapy with universally good results. His patients ranged in age from fifteen to thirty-seven years, seven being over twenty-four and three over thirty. In 1904 Toroeck and Schein[8] reported seven cases of acne vulgaris treated with x-rays. Their results indicated, according to their statement, that the x-ray was the most effective and reliable of any method of treatment known up to that time. In 1908 Sutton,[9] after discussing other methods of treatment, stated that x-ray treatment gave brilliant results at times. In 1912 Fisher[10] had treated twenty-one cases with uniformly good results. In 1917 Hazen[11] had treated forty cases. Twelve cases were cured; fifteen cases were improved.

Up to the time that we abandoned the use of the induction coil and gas tube in superficial therapy, we had treated thirty cases of acne in various stages of development. While we had worked out a dependable technique and tried to keep the factors as constant as possible by following a standard routine, all men of experience know that the gas tube is a variable quantity and that it is next to impossible to repeat the dosage in a given case or to duplicate results in a series of cases. Because of these facts it was necessary to stay well within the zone of safety for the average case. In all lines of medical and surgical endeavor the lack of an absolute standard of technique has often been responsible for mistakes and accidents at the hands of the enthusiast.

The introduction of the large auto-con-

trolled transformer, the broad-focus Coolidge tube and the reliable milliamperemeter have made possible the adoption of an absolute standard technique by means of which therapeutic results may be repeated over and over again with almost mathematical accuracy. The important factors that enter into every x-ray exposure are (1) the voltage, (2) the milliamperage, (3) the distance from the target of the tube to the surface treated, (4) the length of the exposure in minutes, and (5) the composition and thickness of the filters. The factors likely to produce the greatest degree of variation are voltage and amperage. The auto-controlled transformer and a more reliable milliamperemeter have left little to be desired in the way of apparatus.

More attention in the future must be paid to the standardization of x-ray apparatus. The painstaking roentgenologist must have constantly at his command a means of testing his equipment at regular intervals for defects resulting from wear and deterioration. A very slight variation of any one or more of the above five factors will result in a corresponding change in the therapeutic effect obtained. This fact was forcibly brought to our attention several months ago when we were examining several high tension milliamperemeters. After placing these meters in series we were astounded to note that no two indicated the same amount of current passing through them. Which one was correct? We had no means of determining this fact. It was necessary to procure a standard meter before we could determine the error existing in the other meters. We secured a standard milliamperemeter and found that but one out of four of the instruments that we had been using was correct. All were high class meters and were probably correctly adjusted when received from the makers. Two of the milliamperemeters that we had been using extensively, when placed on test with a five-milliampere current, indicated three and seven milliamperes respectively. When the current strength was increased so that the first meter indicated five milliamperes, the actual current in the circuit was about seven milliamperes. When the current was so adjusted that the second meter read five milliamperes, the actual current flowing was about three milliamperes. We believe that every roentgenologist should have a standard milliamperemeter and test all other instruments by it every two weeks, if mistakes and uncertainty are to be avoided when using borderline doses of x-rays.

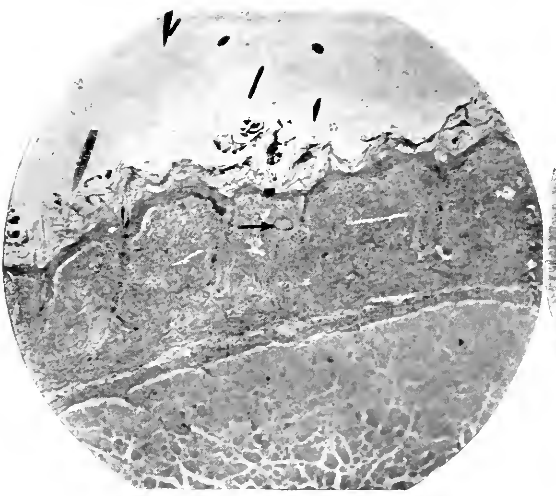

Fig. 5. Skin removed eight days after exposure.

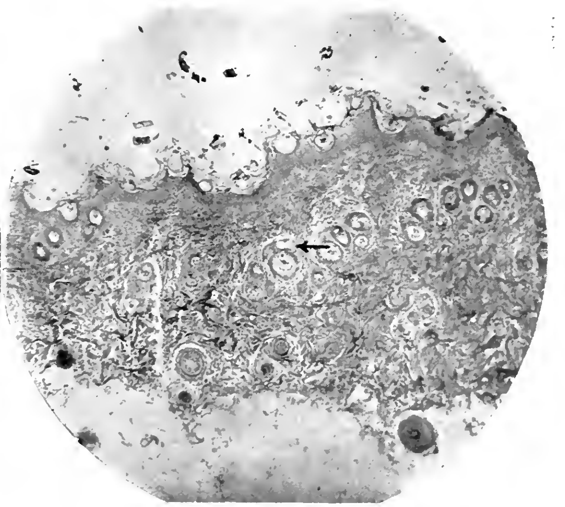

Fig. 6. Skin removed ten days after exposure.

Having overcome the variable milliamperemeter to a practical degree, at least, we began a study of exposures producing a skin

reaction which would be safe in the treatment of superficial skin conditions. After considerable experimental work with an auto-controlled transformer and a broad-focus Coolidge tube the following factors were adopted and have been used regularly and with very gratifying results in the treatment of acne and all superficial skin lesions: (1) A five-inch parallel spark gap; (2) five milliamperes; (3) target skin distance of ten inches; (4) an exposure time of from three to five minutes, and (5) a filter of .5 millimeters of aluminum placed just beneath the tube and a piece of leather placed directly over the area exposed. With these factors a single exposure of twenty-five milliampere minutes will produce a mild degree of reaction in the average skin. This exposure should under no circumstances be repeated in less than a week unless a considerable degree of dermatitis is desired. In the milder types of acne one treatment a week for two or three weeks will usually suffice, but in the deep pustular and indurated types, more active treatment or a much longer period of time and a larger number of treatments will frequently be necessary to accomplish the desired results. In blonds and thin-skinned brunettes, the time of exposure should not be over three minutes. If the first treatment does not produce the desired reaction, as sometimes happens, the period between treatments may be shortened. As a rule, however, one treatment a week under normal conditions will be sufficient to produce good results in all but the most severe types of acne. The Kienboeck quantimeter with its fussy paper strip development, the Holzknecht quantimeter with the barium platino-cyanide pastilles, and the Hampson radiometer which also depends upon a sensitive color reading, have not in our experience been found sufficiently reliable to take the place of the more dependable dosage obtained by factor determination.

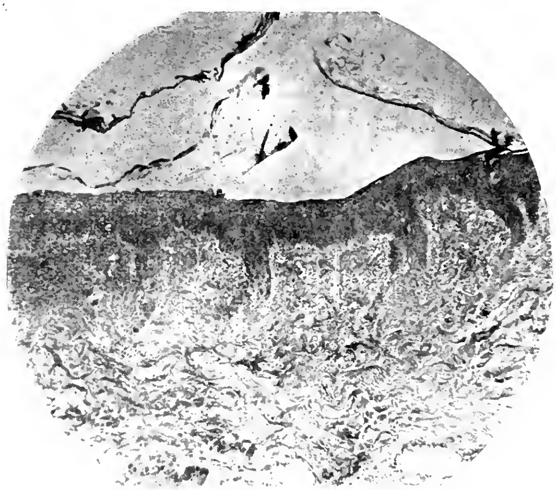

Fig. 7. Skin removed twelve days after exposure. Note the thickened collagen bundles, the absence of sebaceous glands and hair follicles. The thickening of the germinal layer and desquamation of the horny layer.

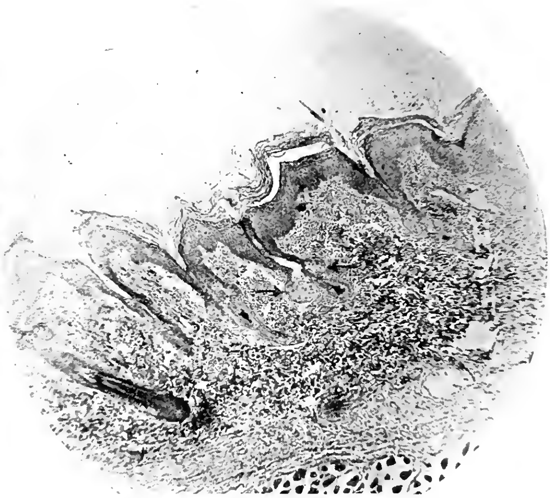

Fig. 8. Large sebaceous glands observed in skin of a guinea pig just outside the borders of a chronic x-ray burn.

In discussing any therapeutic measure we feel that it is proper to attempt to demonstrate as nearly as possible the effect produced on the living organism. One may assume that the effects of the roentgen rays applied to the skin in acne are in some way related to the sebaceous glands, but a histological study of such effects has not so far as we know been carried out. It has not been our good fortune for obvious reasons to

obtain sections of skin from patients under treatment; but we have observed certain changes in irradiated skin of animals which may be of interest. In 1919 a series of experiments on animal skin was carried out by one of us under the direction of Dr. S. B. Wolbach at the Harvard Medical School in Boston. A résumé of this work was published in a previous article.[12] However, no special attention was paid to the sebaceous glands at that time and it now seems worth while to point out some of the changes observed. These experiments were undertaken for the purpose of studying the changes that occur in the skin after it has been exposed to an unfiltered dose of soft rays just sufficient to cause tanning and desquamation. Since this is the dose that appears to give good results in acne it seems logical to assume that the changes in the experimental material are probably very similar to those occurring in the subject receiving treatment.

FIG. 9. Indurated pustular type of acne vulgaris before x-ray treatment. July 27, 1920.

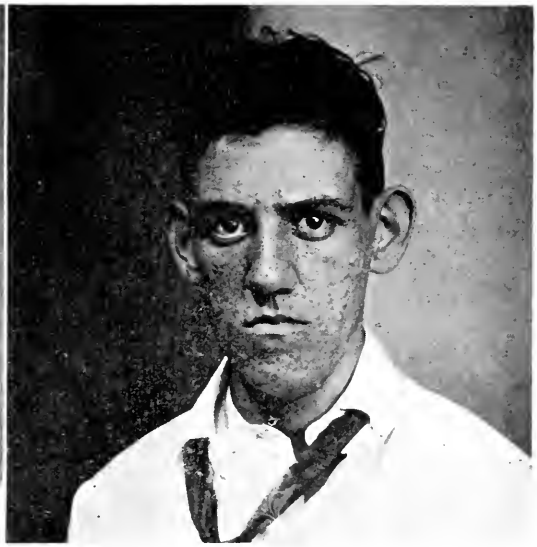

FIG. 10. Same case as Figure 9.

Six white guinea pigs were selected, all of about the same size. The abdomens were shaved and the animals were one after another fastened with their backs down on an animal board and covered with a lead screen in which a square hole measuring 2½ cm. on a side had been cut. This square was so adjusted that it covered a portion of the upper abdomen.

A medium-focus Coolidge tube energized by a Biddle x-ray coil was placed directly above the hole in the shield so that the target skin distance was about twelve inches. No filter was used. The skin of guinea pigs is very resistant and it was found necessary to use forty-five minute exposures with a 2½ inch parallel spark gap and ten milliamperes flowing through the tube to produce the desired results. The six guinea pigs were given this exposure on the same day. One animal was killed every two days thereafter, and the skin of the exposed area sectioned. The pig killed on the twelfth day showed a well-marked tan and a definite desquamation. Other animals receiving this dose and observed for a month never developed ulceration and showed no signs of the irradiation except an alopecia.

Photomicrographs of sections from the exposed areas are shown in the accompanying illustrations. Figure 1 shows a hair follicle and its sebaceous gland in the normal skin of a guinea pig. It is interesting to note how small this gland is as compared with those found in human skin. Figures 2, 3, 4, 5, 6 and 7 represent successive stages in

the development of the roentgen ray dermatitis produced.

The chief changes noted are a thickening and desquamation of the horny layer, a flattening out of the sulci and papilli; a definite thickening of the germinal layer; a gradual shrinking of the hair follicles with loss of the hair shafts; a marked thickening of the collagen bundles of the corium, and a disappearance of the sebaceous glands at about the time that the hair follicles begin to shrink. At the end of eight days there are few such glands in the exposed area, and an occasional one may be observed in the ten-day section, as indicated by the arrows. In the twelve-day section no glands were found. A careful study of the structure of the glands found in the eight and ten-day sections showed no definite evidence of degeneration. This is rather discouraging since these sections seem to indicate that a destruction of the glands must occur at about the time that the hair follicles begin to change. There can be no doubt that the rays have a destructive action on these structures for they are quite plentiful in the sections of normal skin, and their absence in the twelve-day sections can hardly be called a coincidence.

Fig. 11. Illustrating the desquamative stage and the free use of the white wash following the erythema dose of roentgen rays.

It might be assumed that very small doses of rays have a stimulating effect on the glands since they are supposed to stimulate other structures. In support of this assumption, it may be stated that the sebaceous glands shown in Figure 8 are by far the largest observed in any of the material at hand. This photomicrograph shows a section taken just outside of a chronic ulcer in the abdomen of a guinea pig produced by repeatedly exposing the skin with the apparatus already described. Whatever rays reached this region must have been secondary rays coming from the edges of the lead shield. The epithelium is markedly thickened, but none of the other changes observed in tissues receiving direct irradiation are made out.

Since the skin receiving treatment for acne often shows a marked tan and then becomes dry and desquamates, we feel that the sebaceous glands are probably partially destroyed rather than stimulated by the treatment. If this be the case, the other changes described probably occur also. The bearing of such changes on the improvement obtained in acne cases opens up a field for conjecture. If the sebaceous glands are seats of infection in acne, as many invesigators believe they are, it seems reasonable to believe that destruction of such glands by means of the roentgen ray should effect a cure just as it apparently does in cases of tonsillitis, where the enlarged tonsil shrinks down under irradiation and becomes a poor place for bacteria to grow.

SUMMARY

1. Acne vulgaris may be confused with acnitis; but since radiation is beneficial in both conditions a differential diagnosis is not essential.

2. All types of acne vulgaris appear to

improve under roentgen ray treatment provided the proper degree of skin reaction is obtained.

3. Good results depend upon a careful application of definite doses of rays accurately measured with meters calibrated at frequent intervals.

4. We find it impossible at the present writing to describe the histological changes resulting from the irradiation of human skin showing acne lesions. It is to be hoped that such studies will be carried out in the near future.

Fig. 12. Same case on Jan. 25, 1921. Desquamation is complete and the skin is soft and smooth. The cicatricial scars are less pronounced than before treatment.

Fig. 13. Compare Figs. 9 and 10 with Figs. 12 and 13. The improved facial expression and general appearance of this young man are marked. He has resumed an important position that he held with difficulty before treatment.

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THE X-RAY IN DERMATOLOGY*

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DURING the past eighteen months the X-Ray Department of the Massachusetts General Hospital has been treating skin diseases under a plan slightly different from that formerly employed. One morning a week, and part of the time two mornings a week have been given over to the treatment of these conditions. It is my intention to report briefly:

1. Upon the amount of work which this clinic has done.

2. In a general way, the methods of treatment used in this class of cases.

3. The results which have been obtained during this period.

I. From October, 1919, until April 1, 1921, a year and a half, the total number of treatments for cutaneous conditions has been 656. There have been 989 visits to the clinic for this group of cases. The number of different cases which have been under treatment is 179. Eighty per cent of these cases include the following diseases:

1. Ringworm of the scalp, 45 cases, including both the ordinary form and the cases of favus.

2. Pruritus, 30 cases, including cases of itching, both local and general in character, and of more or less indeterminate origin.

3. Epithelioma, the superficial cutaneous cancers, usually of the basal-cell type, 25 cases.

4. Eczema, 14 cases, mostly chronic infiltrated cases.

5. Acne, 13 cases.

6. Sycosis vulgaris, the pyogenic folliculitis of the bearded area, 12 cases.

The other 20 per cent of the cases include eighteen other diagnoses, only comparatively few of any one diagnosis being treated.

II. In speaking of the methods which have been used in the treatment of these skin conditions, for the sake of convenience I am dividing these cases into four groups.

1. The first group includes those cases in which the treatment has been given by unfiltered rays in small doses; that is, in fractional doses of one fourth to one eighth of the amount necessary to produce erythema on the average skin, the treatments being given every week or every two weeks. This type of treatment has been given to more or less generalized superficial conditions; for example, puritus, eczema, acne and sycosis.

2. The second group includes those cases which have been treated with the unfiltered ray in an amount necessary to produce falling out of the hair, that is, an epilating dose. This amounts to approximately an erythema dose on a sensitive skin. Only one treatment has been given to these cases, which include cases of ringworm and favus.

3. The third group includes those cases to which an unfiltered, rather intensive dose has been given; that is, of one and a half times to twice an erythema dose, repeated after three or four weeks if necessary. This has been given to the epitheliomas and to some of the keratoses occurring on senile skin.

4. The fourth group includes those cases to which a filtered dose has been given, using 1 or 2 mm. of aluminum, and using an amount which is just below an erythema dose. This has been repeated every three or four weeks. This class of cases includes rather sharply localized diseases such as keloid, tuberculosis of the skin, lupus, etc.

As factors in the actual treatment of these skin conditions, the following standards of spark gap, milliamperage, distance and time

*Read before the New England Roentgen Ray Society, May 9, 1921.

have been used. The spark gap has been six inches, measured between points. This same gap has been used even when the filtered treatment has been given. Five milliamperes has practically always been used. A distance of eight or twelve inches from the target of the Coolidge tube has been adopted, varied to a certain extent according to the size of the area to be treated, an eight-inch distance being used on the sharply localized conditions. Occasionally a 16-inch distance has been used on the more generalized conditions and the time increased proportionately. The time has been varied in accordance with the result desired. On the particular apparatus employed in this series a little less than two minutes has been found to produce satisfactory epilation at 8 inch distance, without a filter. For filtration 1 millimeter of aluminum has been used, 2 millimeters occasionally, and 3 millimeters very seldom. In the treatment of ringworm of the scalp the usual Kienboeck-Adamson method of application has been employed, giving one epilating dose to each of five areas.

III. The results which have been obtained may be divided more or less arbitrarily into three groups:

1. Those diseases in which the results have been satisfactory. In this group are certain diseases which respond more satisfactorily to *x*-ray than to any other form of treatment.

2. Those in which the results have been only fair.

3. Those in which the results have been unsatisfactory. This group will show certain diseases in which the results of treatment by *x*-ray in this clinic are not as satisfactory as the results obtained in private practice or reported from other clinics, but this paper has been designed primarily to report upon the results obtained in this clinic by treatment during this particular period of time.

GROUP I

Ringworm.—This is one of the diseases which has responded more satisfactorily to *x*-ray than to any other form of treatment. The superiority of *x*-ray treatment over the older methods is emphasized by two facts; (1) That the duration of the contagious period is shortened; (2) that their absence from school because of the disease is very materially lessened. These cases have been treated, as I have said, by the application of an epilating dose to each one of five areas. A satisfactory epilation has been obtained in the majority of cases, though in the course of standardizing the *x*-ray apparatus a few cases have resulted in insufficient epilation on account of the intention to be on the safe side in instituting a somewhat different method. To date no permanent alopecias have been produced, and only a few cases have shown recurrence, these being among the ones in whom insufficient epilation was produced. It has been particularly interesting to me to observe the good results obtained, with only 70 or 80 per cent epilation, in those cases in which after-treatment has been carried out satisfactorily. At the present time we are in the course of treating an epidemic of nine cases which recently appeared at the Waverly School for Feeble-Minded.

Epithelioma.—It is not my intention to discuss the relative value of surgery, radium, or *x*-ray in such cases, but only to discuss those referred to this department. In only three has there been any difficulty in destroying the lesion. These are probably cases of the squamous cell type. Others, as well as the keratoses, have responded to treatment. I believe that thorough curetting of the lesions before treatment renders fewer treatments necessary, and in many cases one, and occasionally two, treatments have been enough. I believe that the dosage should be nearer twice an erythema dose, unfiltered, in order to obtain the most satisfactory results.

Neurodermite.—This term is the name recently applied to a distinct type of chronic eczema, manifesting itself usually by sharply localized, lichenified, excoriated areas. These areas are usually of long duration, and there

is usually intense itching associated with the condition. These cases, without exception, have become well with fractional, unfiltered doses, administered once a week, or once in two weeks.

Mycosis Fungoides.—This is a serious disease, and tends to progress and end in a fatal outcome. The usual methods of treatment are of no avail. *X*-ray treatment is the only form of treatment which has aided the involution of the lesions and relieved the individual of the intense itching which accompanies the disease. Sooner or later, treatment with *x*-ray fails to produce this effect, but in the three cases which have been treated the itching has disappeared and the lesions have disappeared for the present at least. It is not expected, however, that a cure has resulted. These cases have all been in the earlier stages, without much infiltration or tumor formation, and have been treated by the fractional method.

Chronic Eczema.—These cases have been chronic ones with considerable infiltration, with fissures, and oozing, accompanied by the usual marked pruritus. The majority of these cases have been relieved of the itching, the infiltration has faded away, the fissures have closed, and the skin has assumed a very nearly normal feeling and appearance. They have been treated with the fractional, unfiltered dosage, though a few have been given a little larger dosage, perhaps amounting to one half an erythema dose, and repeated at slightly longer intervals. In those cases which have not responded, I believe that they have not been able to return for consistent treatment, or that it has not been possible for the patient to cooperate with us to a certain degree.

Blastomycosis.—The one case which has been treated was given potassium iodid for a period after he first came to the skin clinic. Very little change in the lesion was noted until *x*-ray treatment was instituted though the dose of potassium iodide was kept at the same amount. This case was found to progress much more satisfactorily still after the use of the more intensive filtered treatments.

Pruritus.—In this condition *x*-ray treatment has been a court of last resort in many cases, and it is more or less surprising to observe the number of cases which have been relieved. There has usually been much previous treatment and there have often been pathological conditions produced in the skin by the scratching. In these latter cases, I feel that the best results have been obtained. In the cases which show very little except a few scratch marks, but complain of a good deal of itching, the relief of symptoms has not been as great. In the long-continued cases of itching often seen on senile skins, the results have not been as good. The vulvar and anal cases have almost without exception been relieved. The time has been too short, of course, to state whether this relief is permanent.

GROUP II

In this class are those diseases in which the results as a whole have not been as good, that is, the results would only be classed as fair.

Acne.—These cases have been treated with the unfiltered, fractional ray, giving one fourth to one eighth of an erythema dose to each side of the face, and one half of this dose to the median line. These treatments have been given once a week, or once in two weeks. A series of eight treatments has been given. In about one half of these cases marked improvement has been noted coincident with the treatment, the first improvement noted being in the lessening of the oily appearance of the skin. I believe that a larger number of these cases will improve under more regular treatment and a longer period of treatment than many of them have received. I further believe that the treatment can be given if care and accuracy are used, without any detrimental after effect on the skin.

Tuberculosis of the Skin.—In tuberculosis of the skin, of the verrucous type, the unfiltered rays were used at first without much benefit. Experience has demonstrated that certain of these will respond to filtered treat-

ment which did not respond to the unfiltered dosage. I believe that it is not wise to prolong the treatment of these cases, or to treat them over a long period of time if there is not a fairly prompt improvement.

Favus.—The favus cases are not as satisfactory cases to treat as the ringworm. They epilate just as readily, but there is more tendency to a recurrence of the condition even with a fairly complete epilation.

Keloid.—The few cases which we have had have not remained under treatment, or they have been treated too recently to form an opinion. The treatment in these cases ought to be satisfactory with fairly intensive filtered treatment.

Acne Keloid.—This condition consists of grouped acneiform areas on the back of the neck, associated with the appearance of small keloidal growths which may coalesce. The keloidal parts of these lesions have responded well, but the follicular infections have tended to continue even under epilating doses. These cases have been treated with a fairly intensive filtered ray, sufficient to produce an epilation. About half of these cases have become well.

Parasitic Skin Disease.—I refer to certain probable ringworm affections of the hands and feet, although it has not been possible to demonstrate any of these organisms in scrapings. Two of these cases, particularly, have made remarkable improvement with the unfiltered, fractional treatment.

GROUP III

This group includes those cases in which the results have been unsatisfactory.

Sycosis.—In sycosis there have been about three of the cases which have cleared up coincidently with treatment by the fractional dose method which I outlined at the beginning of this paper. Certain others have not responded even with epilating doses. Others have not been under treatment long enough to draw conclusions.

Lupus Vulgaris.—In lupus vulgaris the treatment of the older, more chronic type, particularly those which have had a lot of previous treatment of one kind or another, has been most unsatisfactory. In those of more recent development in which a fairly intensive filtered dose has been given the result has been more favorable.

Urticaria.—In the cases of chronic urticaria which have been sent to the clinic for treatment the results have been distinctly unsatisfactory.

Hyperhidrosis.—In hyperhidrosis, prolonged sweating of hands, feet and axillae, the cases under treatment have been somewhat relieved by fractional doses of one fourth to one half an erythema dose, unfiltered; but there has not been as much improvement as would be expected from reports in the literature.

Psoriasis.—Only a few cases have been treated, and these have not been treated consistently or for any length of time. The results have not been satisfactory, but I know that in the chronic, thickened, inveterate patches consistent treatment at proper intervals, over a longer period, in unfiltered fractional doses, will show good results.

SUMMARY

X-ray treatment is invaluable in the treatment of ringworm, epithelioma, certain lichenified eczemas, mycosis fungoides, blastomycosis, many eczemas, and many of the itching dermatoses.

It should give good results in a certain number of the cases of acne, acne keloid, tuberculosis of the skin, favus keloid, certain cases of parasitic skin disease, hyperhidrosis, and psoriasis.

TWO CONTRASTING CASES

(1) ADENOCARCINOMA OF THE STOMACH REVEALED BY ROENTGENOGRAMS, BUT NOT PALPABLE ON EXPLORATION BY THE SURGEON; (2) GASTRIC ULCER NOT SHOWN BY THE ROENTGEN RAY, BUT FOUND AT OPERATION

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ROCHESTER, MINNESOTA

THE cases reported here are of interest because one demonstrates the difficulty experienced sometimes by the surgeon in locating a lesion after it has been revealed by the roentgen ray, and one demonstrates that the roentgen ray is not infallible in the diagnosis of gastric ulcer.

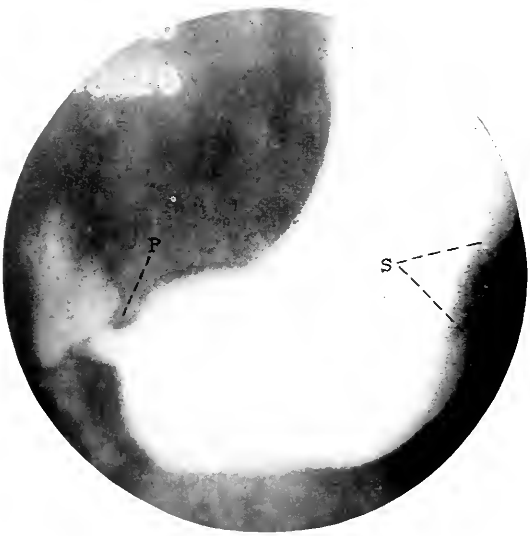

FIG. 1. Deformity of the greater curvature; the posterior wall at S. Note the prepyloric narrowing due to spasm at P.

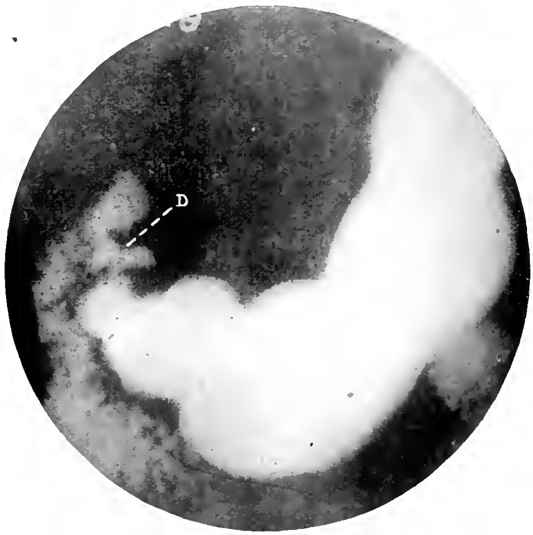

FIG. 2. Duodenal deformity at D. No niche or deformity suggestive of gastric ulcer.

REPORT OF CASES

CASE 343426. Mr. B. J. H., aged forty-five, examined December 10, 1920, had noticed gradually increasing physical weakness for eight months. During the last two months he had had a fairly constant, dull pain in the epigastrium, without definite relation to the taking of food except that it was not so severe when he did not eat. Recently his appetite had been poor. He had vomited several times but there had been no hematemesis and no melena.

The physical examination, the Wassermann reaction, and examinations of the blood and urine were negative. The contents of the stomach did not show free hydrochloric acid. Roentgenograms revealed a lesion on the posterior wall of the stomach near the greater curvature (Fig. 1).

At operation careful palpation of the entire stomach failed to reveal a lesion. Nevertheless, because of the roentgen ray findings and the absence of lesions in any of the other abdominal organs the stomach was

opened. A superficial ulcerated area 2.5 cm. in its longest diameter was found along the greater curvature. It was shallow and there was no palpable induration on the edges in the surrounding tissue. Microscopic examination revealed adenocarcinoma.

The case is of particular interest, because if the surgeon had found a lesion elsewhere in the abdomen he would have regarded it as a cause of the symptoms and would not have opened the stomach. In this event the roentgen finding would have been considered erroneus. The case also illustrates the value of roentgen findings and the necessity for very careful surgical cooperation.

Case 354760. Mr. H. L. K., aged forty-nine, had had gastric trouble for thirty-one years before examination at the Clinic, April 7, 1921. The "indigestion" came in periodic attacks, and lasted for from two to three weeks with intervals varying from one to twelve months. The attacks consisted of pyrosis and epigastric pain coming on about two hours after meals, accompanied by "water brash." The patient had a good appetite; food and soda often afforded moderate relief from pain.

The test meals revealed normal free, and combined acid; the roentgenograms showed evidence of an ulcer of the duodenum and a moderate six-hour retention (Fig. 2).

At operation an ulcer of the duodenum was found and excised. The pylorus was hypertrophied and the stomach dilated. The surgeon was at a loss to account for the large stomach and the retention, as there was no obstruction of the duodenum. Since 55 per cent of gastric ulcers produce six-hour retention from the barium meal, the surgeon made a further examination of the stomach and a small ulcer on the lesser curvature, not discoverable in the roentgenologic examination, was found. In a minority of cases of concurrent gastric and duodenal ulcer, it has been my experience that the roentgen examination discloses only one or the other ulcer.

HEMANGIOMA OF THE DUODENUM

By RUSSELL D. CARMAN, M.D.

Section on Roentgenology, Mayo Clinic

ROCHESTER, MINNESOTA

The case of hemangioma of the duodenum reported here is the first that has been encountered in the Mayo Clinic. Its rare and interesting roentgen and pathologic features seem to justify the report.

Case 356641. Mrs. B. C., aged twenty-two, came to the Clinic April 28, 1921, complaining of having had chronic dyspepsia since childhood. During the last eighteen months she had suffered from two acute attacks of indigestion, lasting about two days, which were considered to be exacerbations of her usual mild attacks with added diffuse epigastric pain and soreness. The milder spells were characterized by nausea and marked frontal headache followed by sour emesis and relief.

The roentgen examination revealed a negative stomach. The duodenum was shadowed as a ring with a translucent center, suggesting the presence of a polypoid growth (Fig. 1). The same appearance was seen at a second examination.

Although the relation between the unusual duodenal deformity and the symptoms was purely speculative, exploration was made. The gall-bladder was negative, the appendix, grade 1, was removed, the stomach was rather thick walled and dilated. The pylorus was wide open; just below the pylorus in the first part of the duodenum was a tumor 7

FIG. 1 (356641). Ring or cyst-like deformity of the duodenal bulb, due to polypoid growth.

cm. by 5 cm. completely filling the duodenum and with a sessile attachment to the duodenal side of the pyloric ring. The tumor was easily enucleated through a transverse incision on the anterior surface of the duodenum (Fig. 2).

Pathologic report: Tumor of the duodenum, hemangioma 5 cm. by 4 cm. (Fig.3).

In a casual examination of the literature I have found but one somewhat similar case reported, that of Winternitz and Boggs. This case was that of a male mulatto, aged sixty-five, who also had multiple subcutaneous hemangio-endotheliomas. At necropsy multiple nodules were found throughout the alimentary canal. The entire intestinal wall was beaded with them; they varied from 2 cm. to 6 cm. in diameter and were found in the esophagus, duodenum, throughout the small

FIG. 2 (*above*). Tumor removed from the first portion of the duodenum.

FIG. 3 (*below*). Hemangioma bisected.

and large intestine, and, as subsequently shown on histologic examination, also in the stomach. No roentgen examination of the digestive tract had been made.

BIBLIOGRAPHY

WINTERNITZ, M. C., AND BOGGS, T. R. A unique coincidence of multiple subcutaneous hemangio-endothelioma, multiple lymphangio-endothelioma of the intestinal tract, and multiple polypi of the stomach undergoing malignant changes, associated with generalized vascular sclerosis and cirrhosis of the liver. *Bull. Johns Hopkins Hosp.*, 1910, xxi, 203-212.

REPORT OF A CASE OF OSTEOMA

By JOHN H. LAMBERT, M.D
LOWELL, MASSACHUSETTS

OSTEOMATA, or osteochondromata are not of rare occurrence, and this case, referred by Dr. A. R. Gardner to me for roentgen diagnosis, is reported not because of the rarity of its type, but on account of its rather unusual size and the interesting features attending its removal.

History.—George G., thirty-six years old, native of Greece, railroad laborer. Father died at seventy-five of pneumonia, mother at seventy of the same disease. Personal history good. Had pneumonia in 1906.

FORMER OPERATIONS.—Scar upper right maxillary region, kicked by a horse, stitches taken.

Chief Complaint.—Growth on right upper humerus. General condition of patient good.

Clinical History.—Patient noticed when in the Greek army, in 1904, a lump on the right shoulder, no pain or discomfort. No interference with the use of the arm in the beginning, but of late a very slight disability, though not marked. General health apparently very good. No loss of strength or weight.

Physical Examination.—Hard, irregular, lobulated mass firmly attached to upper one-third of right humerus, outer aspect. No tenderness. Solid tumor. Physical condition otherwise negative as regards this case.

X-Ray Report.—Attached to the upper third of the right humerus is a large, rounded, dense body 4 inches by 6 inches, showing structure of a bone-like formation, apparently bounded by a definite line and seeming to spring from the shaft about four inches from the head of the humerus on the antero-external surface by an apparent neck about an inch in thickness. The growth extends nearly to the acromion process, partially overcapping the outer portion of the shoulder joint and interfering with its function. The bone structure in the upper part of the humerus is not as well defined as normal, and there appears to be slight rarefaction of the bone in this area. Conclusion: Osteoma arising from a small neck from the upper third of the humerus.

Operation (Performed by Dr. A. R. Gardner at Lowell General Hospital, June 23, 1919).—Incision over right deltoid commencing at about acromion process, extend-

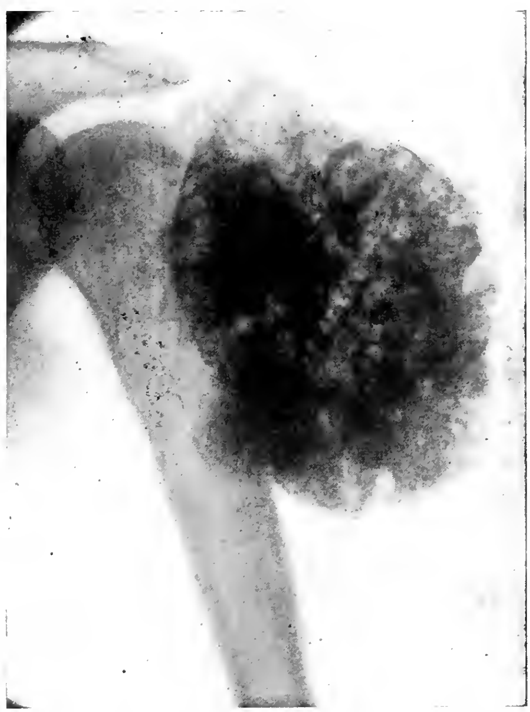

FIG. 1. Roentgenogram taken before operation.

ing down arm on inner side of tumor to just a little below middle of arm. Deltoid muscle split, tissue pushed back from tumor on either side. The base of tumor firmly attached into upper third of humerus by a broad base and base extended through the great trochanter into the joint. Larger part of tumor chiseled off rest of tumor, removed by means of chisel and rongeur forceps. Hemostatsis attended to. A few interrupted

sutures inserted in split deltoid. Cigarette drain placed up to capsule; capsule of joint sutured. Interrupted S. W. G. sutures in skin. July 6th; all healed except small area about the size of a dime from which drain was removed, perfectly clean, no evidence of sepsis.

Pathological Report: Gross description. —The specimen consisted of several masses of bone, the largest of which was the size of a grape fruit. The outer surfaces of these bony masses resembled multiple cysts. Histological description: Microscopical examination of specimen shows bone cells. Diagnosis: Osteoblastoma (benign).

Postoperative *x*-ray examination, July 11, 1919, shows that osteoma has been completely removed from shaft of humerus, and there has been thorough eradication of the neck from which it arose, leaving a gouged-out area at the site of the neck. The surface of the bone shows a considerable area on its outer aspect to which the tumor had undoubtedly been attached. There is evidence of a few spicules of bone remaining unattached in the area formerly occupied by the tumor. At this time the function of the shoulder joint seems to be normal.

It is interesting to note that the difficulties of operative removal were considerable, owing to the fact that the tumor had become firmly attached to the shaft of the humerus above its origin, and had involved joint structures, so that a portion of the capsule was necessarily sacrificed in its removal. Many osteomata are slow growing and never attain sufficient size to cause disability, or interfere with function; but it would appear from this case that it would be advisable, on account of the fact that the growth is apt to be toward the joint, to examine them by *x*-rays periodically and determine the point at which they should be removed, in order to avoid encroachment upon other structures that might result in permanent damage and disability.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M.D., *Editor* · Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921

Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

IMPORTANT RAILROAD INFORMATION*

Reduced fares on the basis of the certificate plan have been granted by the following passenger associations to the Twenty-second Annual Meeting of The American Roentgen Ray Society:

Trunk Line Association: N. Y. (east of and including Buffalo, Niagara Falls, Suspension Bridge and Salamanca), New Jersey, Pennsylvania (east of and including Erie, Oil City and Pittsburgh), Delaware, Maryland, District of Columbia, Virginia and West Virginia (east of and including Wheeling, Parkersburg, Kenova, Orange and Norfolk).

Central Passenger Association: Territory west of Buffalo, Niagara Falls, Salamanca, Pittsburgh, Wheeling, Parkersburg, and Kenova to and including Chicago and St. Louis, and north of the Ohio River, including Cincinnati, Louisville and Cairo.

Western Passenger Association: Territory includes stations in Colorado, Idaho, Illinois, Iowa, Kansas (except points on and east of St. Louis–San Francisco Railway, Kansas City, Mo., to Baxter, Kans., via Girard and Cherokee, Kans.), Missouri (points on and north of Missouri Pacific Railroad, St. Louis to Labadie, thence Chicago, Rock Island and Pacific Railway, Labadie to Kansas City, Mo.), Minnesota, Montana, Nebraska, North Dakota, Northern Michigan, South Dakota, Utah, Wisconsin and Wyoming.

Southwestern Passenger Association: Territory southwest of St. Louis, including Texas, Arkansas, Oklahoma, Missouri (south of Missouri River), and Louisiana (west of Mississippi River).

Southeastern Passenger Association: Territory south of Ohio and Potomac and east of Mississippi Rivers.

If the requirements of the Passenger Associations are carried out, there will be *a saving of 25 per cent* on the round trip, which should be worth while for all concerned.

All persons traveling from any point within the territory above named should, when purchasing tickets, ask the agent for a *Certificate* for each ticket purchased (one certificate will *not* do for an entire family or party). This Certificate should be presented at the desk when registering at the meeting.

There will be a railroad man in attendance, and if not fewer than 350 Certificates are turned in, they will be validated and returned to the owners.

The presentation of a validated Certificate will entitle the holder to purchase return ticket at one half of the regular fare. The essential point in this transaction is that no reduced fares will be allowed unless 350 Certificates, at least, are turned in.

We understand that Certificates are not on hand at all ticket offices, but any ticket agent will direct the purchaser where such Certificate may be obtained.

It should be noted that the New England railroads have not agreed to this plan. It is suggested to travelers from New England that tickets be purchased to New York City and from there tickets with Certificates be obtained to Washington.†

A large attendance is expected at the meeting; hence there should be no trouble in securing the reduced fares PROVIDED that 350 will take the trouble to ask for Certificates, which will be available with tickets purchased Sept. 23 to 30, inclusive.

*A detailed letter regarding this matter will be sent to all members of The American Roentgen Ray Society prior to the meeting. Others may obtain this letter by addressing the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

†At the time of going to press no information has been received as to the action of the Transcontinental Passenger Association covering the Pacific Coast and other far western territory.

TWENTY-SECOND ANNUAL MEETING

The program for the annual meeting of The American Roentgen Ray Society, complete to date, is printed below.

The interest in roentgen therapy, which appears to be quite universal this year, has made it seem necessary to give to therapeutic subjects an even larger proportion of the program than was originally intended.

Those who have not yet sent in abstracts of their papers please do so at an early date.

PROVISIONAL PROGRAM

Cancer of the Uterus. Henry Schmitz, M.D., Chicago.

The Treatment of Brain Tumors by Radiation. Henry K. Pancoast, M.D., Philadelphia.

Progress of Deep Roentgen Therapy. (The Caldwell Lecture.) Dr. Réné Ledoux-Lebard, Paris, France.

Symposium on Therapy of the Thyroid Gland

Some Observations on the Treatment of Hyperthyroidism with X-Rays. George W. Holmes, M.D.

Radiotherapy of the Thyroid. A. F. Tyler, M.D.

The Treatment of Carcinoma of the Thyroid by Radiation. George E. Pfahler, M.D., Philadelphia.

Thyroid Therapy. R. G. Allison, M.D., Minneapolis. Dr. Holmes will open discussion.

The Roentgen Ray in Dermatology. George W. MacKee, M.D., N. Y., and Henry H. Hazen, M.D.,

The Present Status of Deep Roentgen Therapy in Europe, from a Clinical Standpoint. W. H. Stewart, M.D.

Therapy of Superficial Growths. C. F. Bowen, M.D.

Minimum Erythema Dose with Diagnostic Voltages. Arthur W. Erskine, M.D., Cedar Rapids, Iowa.

The Iontoquantimeter in Measuring Dosage for Deep Therapy. Reginald Morton, M.D., London, Eng.

New Technique for the Vertical Examination of the Sphenoid with Demonstration of the Special Film Holder. George E. Pfahler, M.D., Philadelphia.

The Stereo-Fluoroscope. (Dr. Morgan's stereofluoroscope will be demonstrated under actual working conditions.) J. D. Morgan, M.D., Montreal, Can.

Paget's Disease; Roentgen Studies Relating to its Etiology and Differential Diagnosis. L. T. LeWald, M.D.

Symposium on Education in Roentgenology

Undergraduate Education. F. H. Baetjer, M.D., Baltimore, and H. K. Pancoast, M.D., Philadelphia.

Graduate Education. Geo. W. Holmes, M.D., Boston, L. Jaches, M.D., N. Y., and J. S. Shearer, Ithaca, N. Y.

Gastro-enterostomy Failures Turned into Successes by Appropriate Treatment Indicated from X-Ray Examination. A. H. Pirie, M.D., Montreal, Can.

The Present Status of Pneumoperitoneum as a Diagnostic Aid. James T. Case, M.D., Battle Creek.

Pulmonary Tuberculosis. L. Jaches, M.D., and H. Wessler, M.D., New York City.

Benign and Malignant Gastric Ulcers from the Roentgenologic Viewpoint. Russell D. Carman, M.D.

Ossification of the Meninges. H. M. Imboden, M.D., and C. A. McKendree, M.D., New York City.

Dental Roentgenography in the Light of Clinical and Pathological Findings. Allan Scott Wolfe, D.D.S.

(Subject not received.) Willis F. Manges, M.D.

X-Ray Treatment of Diphtheria Carriers. P. M. Hickey, M.D., Detroit.

Dr. Witherbee will open discussion.

Demonstration of Simplified X-Ray Unit for Treatment of Tonsils and Adenoids, Exophthalmic Goiter, Tubercular Glands of the Neck and Enlarged Prostate. W. D. Witherbee, M.D., New York City.

(Subject not received.) John W. Pierson, M.D.

Value of Interstitial Radiation. Douglas Quick, M.D.

X-Ray Evidence of Abnormal Small Intestinal States Embodying an Hypothesis of the Transmission of Gastro-intestinal Tension. (Illustrated by Lantern Slides.) R. Walter Mills, M.D., St. Louis.

The Relation of Temperature Changes to Roentgen Ray Skin Reaction. Charles L. Martin, M.D., and George T. Caldwell, M.D., Dallas, Tex.

The Efficiency of the Bucky Diaphragm Principle. R. B. Wilsey, Rochester, N. Y.

The Roentgenological Aspect of Sprengel's Deformity (with lantern slides). Edward S. Blaine, M.D.

Epithelioma of the Cornea. D. Y. Keith, M.D.

Filtration and Scattering. J. S. Shearer, Ithaca, N. Y.

Pyelitis of Pregnancy. F. M. Hodges, M.D., Richmond.

Studies on Injected Kidneys, W. K. Lim, M.D.

Studies in Roentgen Ray Deep Therapy: 1. Studies on the Penetration of Rays in Tissue; 2. Electrical Studies. Prof. F. Dessauer, Frankfurt am Main.

The Operation of X-Ray Tubes at 200,000 to 300,000 Volts (Maximum). W. D. Coolidge.

Limitation of X-Ray in Fracture Work. Roland Hammond, M.D., Providence, R. I.

Use and Abuse of Radium and the Roentgen Ray in Treatment of Epithelioma. Russell H. Boggs, M.D.

The Lumbar Spine and Sacro-Iliac Joints. M. B. Palmer, M.D., Rochester, N. Y.

The Diagnosis and Removal of Foreign Bodies from Bronchus and Esophagus. C. F. Bowen, M.D.

The Differential Diagnosis of Ulcer, Adhesions, and Congenital Membranes Involving the Extreme Pyloric End of the Stomach and Cap and their Surgical Significance. Louis Gregory Cole, M.D.

Possibilities of Treatment in Pancreatic Carcinoma. G. E. Richards, M.D., Toronto, Can.

Intensive Therapy in Germany. Samuel Stern, M.D.

The lantern slide exhibits at meetings of The American Roentgen Ray Society have always been a very interesting and instructive feature. According to custom, one evening has been reserved for this purpose, but up to the present time only a few members have indicated their desire to show slides. Presentation of slides is not confined to members of the Society. Any guest of the Society may reserve a place on this program, but names will be listed in the order received.

Please send in your name as soon as possible and indicate the number and nature of the slides you will show.

Following precedent, we are publishing in this issue the portrait of the President of The American Roentgen Ray Society, Arthur C. Christie, M.D.

CORRESPONDENCE

FROM COMMITTEE ON SAFETY

At the last annual meeting of the American Roentgen Ray Society it was voted to appoint a committee on safety.

In order that this committee may give proper consideration to the various matters involved, they request the cooperation of the medical profession in the collection of data in regard to injuries due to the operation of x-ray apparatus.

Readers of this Journal are requested to give the committee any information they may have. No names of institutions, physicians or patients need be given, and information will be regarded as confidential in any case. The following list suggests some of the information that would be of service. As far as possible the exact conditions under which the injury occurred should be given.

ELECTRIC SHOCK

1. Number of injuries observed or reported.
2. The extent and nature of each.
3. Incurred during (*a*) Treatment,
   (*b*) Fluoroscopy,
   (*c*) Radiography.
4. Type of apparatus in use:
   (*a*) Large transformer,
   (*b*) Small type transformer,
   (*c*) Induction coil.
5. Control resistance: Auto transformer.
6. Type of support on which the person injured was placed:
   (*a*) Standing on floor of { tile, concrete, wood
   (*b*) On wooden table,
   (*c*) On a metal table.
7. If the latter, was it grounded?
8. Any information as to actual or supposed special conditions at the time of injury.
9. Was the tube or apparatus damaged?
10. Was the accident due to any failure of apparatus?
11. Was the room damp or wet?

INJURY DUE TO x-RAYS

1. Extent and seriousness, i.e.,
   (*a*) Simple dermatitis,
   (*b*) Second or third degree dermatitis,
   (*c*) Telangiectasis,
   (*d*) Temporary loss of hair,
   (*e*) Permanent loss of hair.
2. Was the patient being (*a*) fluoroscoped, (*b*) radiographed, (*c*) treated?
3. What type of apparatus was used?
4. What current—spark-gap—distance—filter—time, was used?
5. Was any method of measuring skin dose employed?

It is the aim of this Committee to determine the prime causes of accidents and the best means of preventing them, without interfering with the utilization of the rays or causing needless expense. Also a few simple rules for the guidance of manufacturers and roentgenologists may be worked out.

Communications may be addressed to any member of the Committee, or to Miss Doris Keeler, Sec., Rockefeller Hall, Ithaca, N. Y.

W. D. Coolidge, Schenectady, N. Y.
P. M. Hickey, M.D., Detroit, Mich.
H. K. Pancoast, M.D., Philadelphia.
G. W. Holmes, M.D., Boston.
J. S. Shearer, Ithaca, N. Y.

To the Editor:

Dear Sir: There seems to be a considerable difference in opinion with reference to the positioning of an x-ray tube when producing stereoscopic pictures. There follow a number of varied opinions from different sources, including one of the largest manufacturers of x-ray equipment, one of the largest manufacturers of photographic supplies, a doctor in the United States Public Health Service, and one of the leading optical manufacturers.

The writers of these opinions do not wish to have them published over their names, but they serve to illustrate the point in question.

I also have the following comments of one of the above authorities with reference to the article which appeared in The American Journal of Roentgenology for November, 1920, (page 564), showing the application of the stereoscopic tube-stand adopted for the examination of the skull, as used in the Department of Roentgenology at the Union Medical College at Pekin, China.

"I believe that in China the method of stereoscopy as outlined in the article to which you referred me might be very adequate. I am not convinced that in America the method outlined is at all standard. I am unswerving in the belief and scientific conviction that stereoscopy consists in shifting the central ray the distance that the eyes are apart; *and that this shifting must be equal for all parts stereoscoped.* In China the method by you described does not even show how much shifting is done, and if it did show it would

still be more for that part of the body nearest the tube than for the part of the body nearest the plate."

Other opinions follow:

"Our opinion is that if we assume a line exactly at right angles to the plane to be photographed, that is a perpendicular line to the plane, then one picture should be made with the target of the tube set at a distance from this line equal to one half the normal eye separation or approximately 1¼ inches, and then it can be rotated about its horizontal axis so that the target is pointed at the point on the object intercepted by the perpendicular line referred to. The second position of the tube would be the same distance the other side of the line with the target again rotating until its rays intercept the object at the point of the normal. In other words, the two pictures, in our estimation, should be made with a separation along a horizontal line of approximately 2½ inches between the two locations of the target and with the tube rotating *so that in each case the target would be pointed to the same spot on the object.* This is a procedure necessary in ordinary photography in order to secure stereoscopic pictures.

"The theory of stereoscopy is based on binocular vision in which two images must be presented, each image differing from the other in its focal angle to an amount equivalent to the difference between the visual axis of the observer's eyes (60 millimeters, normal). In making the tube shift Kennon Dunham very tersely explains on page 6 of his reprint entitled *X-Ray Chest Manual,* reprinted from the transactions of the 14th Annual Meeting of the National Tuberculosis Association: '*The tube must move through a plane parallel to the plate.*' The essential pith of my argument is that the tube should not be tilted but should be moved in its entirety in a plane parallel to the plate.

"Taking into consideration the physics and practical construction of modern *x*-ray tubes, there would be *no fundamental difference in making stereoscopic negatives whether the tube was shifted in a plane or rotated in the arc of a circle;* the only condition which it would be necessary to fulfil being that the circle of rays covered on the plate satisfactorily covered the subject.

"There, of course, might be a theoretical case where a long narrow cylinder was used where this would necessarily have to be tilted in order to cover the object, but in the average practice it would certainly not be the case. Even in the case of the use of the Bucky-Potter diaphragm the writer doubts

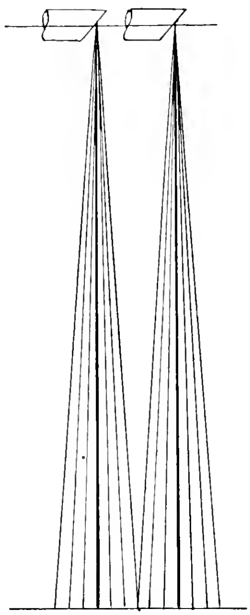

FIGURE 1

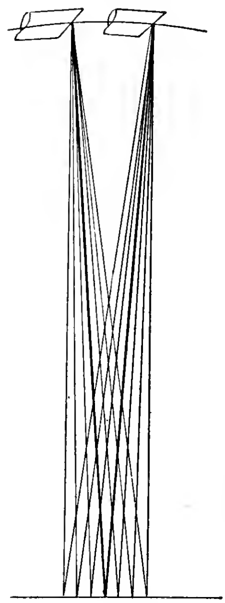

FIGURE 2

if there would be any necessity of shifting the tube in the arc of a circle.

"I do not see that it makes any difference *whether the tube is rotated or not* so long as the required lateral movement of the focal spot is obtained and the opening in the shield or side of the cone (if they used one) does not cut off any of the required beam of rays."

Figures 1 and 2 illustrate the two types of position for stereoscopic radiography. Figure 1 shows the target of the tube moved through the proper distance, but in a plane horizontal with the plate. Figure 2 shows the target of the tube moved through the proper distance but through an arc, so that the central ray is at all times focused at the same spot on the plate.

At first glance, it would appear that we have two entirely different conditions. Con-

sidering, however, the characteristics of the field of examination of x-rays from the target of the tube, there is practically no difference between the effect produced on the plate in either Figure 1 or Figure 2.

In order to make this point clear, we must get the idea in mind that the x-ray emanates from a point source, and that it is emanating from this source in all directions in front of the plane on which this point is located, the strongest rays of course at the very center, and gradually diminishing to nothing on a line parallel to this plane.

After we have this clearly in mind, and looking at Figure 1, we find that there are in effect only two points at which the rays strike the plate at a true perpendicular, and that is at a point directly below the target in each position. At any other point on the plate the rays must necessarily strike at a varying angle.

Now considering Figure 2, where we have rotated the targets in such a manner that they focus in either position on the same point on the plate, we have the two central rays both hitting the same spot, while the weaker rays go correspondingly around this spot.

It will be seen that if we take the rays from the target in Figure 1 that come together in the central part of the plate, or in other words, the center distance between the two spots directly below the target, they strike the plate at the same angle as the two central rays in Figure 2, which emanate from the targets rotated through their distance rather than move through the parallel plane.

It is obvious in the same connection, that if we were attempting to take a stereoscopic radiograph of a grain of corn, or other small article, less than the distance through which we move the center point of the target, and if the only x-ray that was given off was the one central ray, we would not get any radiograph of this small object if placed at the central point between the two points directly in front of the focal spot on the target.

It is equally obvious that with a body of any size in position to be radiographed, a line drawn from the focal spot from the target to any spot on this body and continued through that spot to the plate, will strike the plate at the same angle, irrespective of whether the target is slightly tilted or in such position as to direct the central ray perpendicularly towards the plate.

Thus it appears that as long as the target is moved the required distance each side of the center, it makes no difference whether the target was moved on a straight line keeping the central ray directed perpendicularly towards the plate, or whether the target was moved through an arc and tilted, so that the central ray is directed towards the plate at an angle.

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326 Broadway, New York.

OBITUARY

William Ironside Bruce, M.D. (Aberdeen)

"Do you happen to know anyone who wants to take up an x-ray practice in the west end of London? I have been told to give up x-ray work and get out into the country." This was the substance of the last letter I had from my friend Bruce just a week before the news of his death. He knew that the x-rays had marked him down and that there was one, and only one, course open to him, namely, to haul down his colors and to go right away from the work he loved and the position he had built up with much labor. There was no whimpering, no self-pity! He took his sentence like a soldier and hoped that he would regain health and strength when the effect of the radiations to which he had been unduly exposed, had worn off. This, however, was not to be. The aplastic anemia from which he suffered, and which he and the medical officers in attendance attributed to x-rays, caused his death on March 21, 1921.

Ironside Bruce, born in 1876, was the son of a medical man practicing at Dingwall in Aberdeenshire. He went to the University of Aberdeen, taking his degree there in 1900. The call of war took him to South Africa as a surgeon, and during this service he came in

contact with those who were doing x-ray work in the field. His keen interest in the subject was aroused, and when he returned he took up a post as assistant to the late Sir James Mackenzie Davidson at Charing Cross Hospital. When his chief retired, Bruce was appointed to fill the post, and as chief of this department he worked until his death. In addition he undertook the charge of the x-ray department of the Great Ormond Street Hospital for Children.

Of a mechanical turn of mind, Bruce did a great deal in the early days in designing apparatus, and there are several simple and effective contrivances that bear his name and are still in constant demand, especially his couch with its "plumb-bob." During the war, he worked in the x-ray department of the military hospital to which he was attached, on the subject of the extraction of foreign bodies. His x-ray room was made into an operating theater, and his director operating couch was so contrived that, having located the foreign body, a director needle could be swung into position, into the wound, and would direct the surgeon straight to the foreign body.

When the idea of a diploma in radiology was mooted, Bruce was a very active supporter and took a keen interest in the project. Later on, when the scheme was put into effect, he took a share in the lecturing and was one of the most successful of teachers.

But first and foremost, Bruce was a man —a most lovable man, with a boyish exuberance of vitality and a charm that won affection wherever he went. Nobody could be with him without feeling the force of his personality and the good-humored joyous life of the man who was still a boy at heart. He was particularly fond of children, and nearly always succeeded in quieting their fears when they came as patients. His knowledge of human nature was profound, and in addition he had that intuitive perception and unconscious power of deduction that made his opinions of very great value. In the interpretation of radiograms his apparently lightning diagnoses were extraordinarily accurate, for he had a long experience, a good memory, and back of it all this unconscious reasoning and sound common sense that made his opinions of inestimable value.

In Bruce's death we have sustained a very great loss, the loss of a leader who had made his mark, and whose fearless and outspoken opinion was often the deciding factor in difficult situations.

A. E. Barclay.

AMERICAN RADIUM SOCIETY *

WHEREAS, During the past year there have been removed from our midst and from our membership by death three physicians prominent in the inception of this Society and in the development of the science of the therapeutic employment of radium, viz.:

Dr. Walter B. Chase, of Brooklyn, a charter member and one of the first Americans to employ radium for therapeutic purposes;

Dr. Howard W. Longyear, of Detroit, the well-known gynecologist, whose interest was helpful in the very beginnings of this organization, and whose efforts we shall long remember as contributing to the establishment of radium as a recognized adjunct in gynecology;

And Dr. Henry Harrington Janeway, head of the Radium Department of the Memorial Hospital, New York, especially notable for his efforts to standardize dosage and render the application of radium more accurate, for his early work in the treatment of uterine carcinoma particularly, and as being first in America to use radium emanation buried in tumor growths;

Therefore be it

RESOLVED that this Society express to the bereaved families of these deceased members our sincere sympathy in their loss; and further be it

RESOLVED that a copy of these resolutions be spread upon the minutes as a token of our gratitude and pride in the accomplishments of these departed members.

*Resolutions adopted by American Radium Society at its Sixth Annual Meeting, June 6, 1921.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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SOME RECENT ADVANCES MADE IN FRANCE ON THE TECHNIQUE OF THE ROENTGEN DIAGNOSIS OF DISEASES OF THE HEART AND ITS VASCULAR PEDICLE*

By GONZALES MARTINEZ, M.D.

SAN JUAN, PORTO RICO

HAVING just spent a year in Paris, where I went with the special intent and purpose of studying and familiarizing myself at first hand with roentgenological methods adopted in France, I thought it would perhaps interest you if I gave you a brief summary of my observations of the technique there in use for the diagnosis of the heart and its vascular pedicle.

To be perfectly frank, I prefer and consider most practical American roentgenological methods. Yet I must confess that in the limited field of cardiac roentgenology I have experienced a most agreeable surprise in observing the remarkable progress of the French investigators.

Originating in Germany with the works of Moritz, Groedel, Levy-Dorn and others, these particular methods of exploration, with the new impulse added later in England and America by Clayton, Merrill, Crane, and many others, have lately been perfected to such an extent that without fear of exaggeration one may state that the roentgenological examination of the silhouette of the heart and its large vessels occupies a place as important as that already accorded to such similar studies in the pathology of the digestive apparatus.

Many French authors have shared in this progressive movement; among them will always be mentioned the names of Destot, D'Arcelin, Béclère, Barjon, Beaujard and Thoyer-Rozat; but to Vaquez and Bordet is due the chief credit for the perfection and introduction into common practice of these new procedures, thus founding, as it were, a real school of cardiac roentgenology.

Not that they disregard in the least the real value of teleroentgenography in this particular branch of diagnosis, but yet Vaquez and Bordet prefer the fluoroscopic methods. In fact, the teleroentgenogram, although of the greatest value for permanent record of certain phases of position, actual form and relations of the cardiovascular shadow, eliminating the deformities and distortions of oblique projections, has nevertheless the disadvantage that it requires a considerable expenditure of electrical energy and the costly installation of an expensive equipment, which not everyone can afford, and at the same time they give little precise information in reference to functional disturbances. Thus teleroentgenography can hardly give us information about cardiac displacements during the movements of respiration; nor about the mobility of the cardiac apex; nor the

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14-17, 1920.

expansive movements of the diaphragm; nor the respiratory profile of the thorax. And even supposing we could obtain such facts from the roentgenographic plate the procedure is so costly and complicated as to rob it of its practical value.

On the other hand, teleroentgenography could never show us exactly those modifications in volume of the left auricle; the alteration of the ventricular beats; the precise point of origin of the upper outline of the left ventricle; the angle of disappearance of the apex of the heart behind the shadow of the vertebral column as the subject is being examined in the right posterior oblique position; nor the index of ventricular depth of Vaquez and Bordet, all of which details are of immense value for the diagnosis of local affections of the cavities of the heart.

The roentgenoscopy of precision, on the other hand, as Vaquez and Bordet say, "makes the heart of the living subject appear to the observer just as it could be seen on the autopsy table, less deformed perhaps, because it is being studied while animated by the current of the blood."

Furthermore, this is a method of easy practical realization. Although it requires a certain amount of technical ability in the operator, complete knowledge of the normal, topographic and pathological anatomy of the heart and its great vessels, as well as of the various symptomatic manifestations of its different lesions, yet it does not necessitate, as does teleroentgenography, any expensive installation. In fact, an x-ray generator of moderate power and a simple vertical roentgenoscope provided with a suitable diaphragm and some device that would allow the tube to move independently of the fluoroscopic screen (while this can be fixed at different altitudes in front of the patient's thorax, in a plane perpendicular to the normal rays, and at variable distances from the tube) are all that is necessary.

In this respect I may mention that, in my opinion, the American roentgenoscopes are superior to the French, not only because of their adaptability and ease of movement, but also because of the greater protection afforded by them to the observer and his assistants.

Vaquez and Bordet always examine the patient standing in a frontal position, heels together, so that the biscapular axis is parallel to the screen with the costosternal wall in close contact with the screen, the chin firmly resting against its frame so as to avoid any swinging of the head and the torso. The distance between the target of the tube and the screen, according to the method of Vaquez and Bordet, must always be the same (60 centimeters), because the values that represent the normal indices of the angle of disappearance of the apex of the heart (l'angle de disparition de la pointe) and the depth development of the left ventricle, have already been calculated at this distance.

Having previously made a general inspection of the thoracic walls, the pulmonary field, the mediastinum and the median shadow, one proceeds to the tracing of the orthodiagram. The patient, meanwhile, must breathe very slowly and quietly. Locate exactly the point of origin of the outline of the left ventricle, a point which is recognized as being on that neutral zone on which you can see alternately the oscillation caused by the contractions of the auricles and ventricles. One should also mark on the outline the point where he observes the apex-beats. Once the orthodiagram is finished, Vaquez and Bordet immediately begin to determine the index of depth of ventricular development, using for this purpose a method derived from that which Strohl employs for the localization of foreign bodies. With the patient still standing in this frontal position, you ask him to make alternately forced movements of inspiration and expiration, during which you observe the displacements of the heart and study the inferior outline of the right ventricle as well as the extent of the movements of contraction and expansion of the diaphragmatic dome. The degree of mobility of the apex is investigated by having the patient bend his body to the right and to the left. The character of the cardiac and aortic pulsations will have been noted during the first part of the examination.

Next, the patient is placed in a direct posterior position, having him turn slowly with his left side as an axis, while his right shoulder comes nearer and nearer to the screen; you ascertain the exact position in which the apex of the heart hides itself, disappearing behind the shadow caused by the vertebral column, and then you measure the angle that the biscapular line forms at that moment with a plane parallel to the screen. This is the "angle of disappearance of the apex" of Vaquez and Bordet (L'angle de disparition de la pointe). This angle—which as the index of depth is found increased in all cases of hypertrophy of the left ventricle —is measured by these authors with a goniometer of their own invention.

From these direct positions the patient is put in the oblique positions, which are very important for the investigations of deformities or modifications of volume of the vascular pedicle and of the different cardiac chambers, chiefly that of the auricle and of the right ventricle. The most common of these positions are the right anterior oblique, the left anterior oblique and the right posterior oblique.

On the traced record of the orthodiagram are marked the points corresponding to the extreme limits of the contour of the left ventricle and of the right auricle, which in the accompanying illustration (Fig. 1) are indicated as the points GG′ for the left ventricle, and DD′ for the right auricle; which points are to serve for the tracing of the different diameters with which we are to calculate the global volume of the heart or the partial volume of each one of its individual chambers.

Vaquez and Bordet have adopted the horizontal and longitudinal diameters established by Clayton and Merrill, and they agree that their dimensions are in accord and relation with the weight and muscular development of the individual; but they add that they also vary with the age of the subject, such variations oscillating among average limits, the variation being from 123 millimeters of longitudinal diameter and 110 millimeters of the horizontal, in a subject of from twenty to thirty years of age whose weight does not exceed 60 kilos, up to 142 millimeters of longitudinal diameter by 132 millimeters of the horizontal in a subject past sixty years of age and with a weight of 70 to 90 kilos. The longitudinal diameter is measured by tracing a line from point D in the illustration (the point of intersection

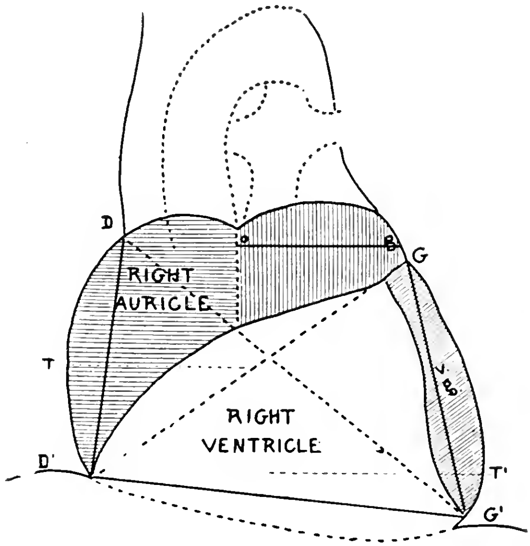

FIGURE 1.

of the outline of the right auricle with the origin of the vascular pedicle) to G′ (the point of the apex beat). It indicates the global development of the ventricles. The horizontal diameter measures the distance from the most salient part of the right cardiac contour, to the most salient of the left, and indicates also the development of the right cavities.

Vaquez and Bordet also utilize the basal diameter of Wenchebach that measures the development of the base of the ventricles, and corresponds to that line which connects points D′ (the point of intersection of the right auricular and ventricular contour) to the point G′ (the upper origin of the left ventricular contour). Its mean normal value is 99 millimeters.

Besides these diameters, important for the investigation of global alterations of form and volume of the cardiac silhouette, Vaquez and Bordet have also introduced new

diameters which facilitate the study of the partial modifications in the outline of each of the cavities. These diameters are:

(A) The left ventricular diameter or the left chord of Siciliano is the line GG′ that unites the base of the ventricle to its apex and measures the longitudinal development of this cavity. The degree of curvature of the left ventricular contour is estimated by the length of the chord of the arc which it describes, dropping from its uppermost point, a line perpendicular to the diameter GG′.

(B) The right ventricular diameter, or line D′G′ that starts from the right cardiodiaphragmatic angle and ends at the apex of the heart, measures the development of the right ventricle. It is not always very easy to determine. It is subject to some sources of error, which, if you know them, you can avoid—the descent of the point of origin of the ventricle below the right cardiodiaphragmatic angle in those pathological stages in which the heart lies on the diaphragm horizontally, and its elevation when the organ is tilted to the right by the hypertrophy and descent of its apex. To trace its chord it is necessary to have recourse to the gaseous distension of the stomach.

(C) The right auricular diameter (DD′) that unites the right cardiodiaphragmatic angle with the cardiovascular angle of the same side, and measures the volumetric development of this auricle.

(D) The left auricular diameter (line og), that connects the most salient point of the left auricular contour with the interauricular septum, arbitrarily placed by Vaquez and Bordet in the mediosternal line. This dimension is not precise and has little diagnostic value; it can be ignored because the volumetric and morphologic modifications of the left auricle can be better studied during the examination of the patient in an oblique position.

The mean normal values of these diameters are: the left ventricle, 70 to 80 millimeters; the right ventricle, 110 to 120 millimeters; the right auricular, 50 millimeters, and the left auricular, 40 to 50 millimeters. The diameter of the left ventricle has in healthy subjects the same value as an index of depth.

The record of these facts upon the orthodiagram and the record of the alterations in volume and contour observed with the examination in the oblique positions and the static and dynamic perturbations disclosed during the course of the roentgenoscopic investigations, taken into consideration with those facts given us from the clinical history, enable us in the majority of cases to make a precise roentgenologic diagnosis of each one of the lesions of the heart and its vascular pedicle, whether congenital or acquired. Just as in other branches of roentgenology, however, this does not mean that there would not occur exceptional cases in which it would be impossible to arrive at a precise conclusion; in such cases the roentgenologist has to restrict himself to pointing out those abnormalities which he has observed.

If the important improvements introduced by Vaquez and Bordet in the technique of the roentgenological examination of the heart are of great interest, of still more importance are their contributions to our knowledge of the normal appearance and pathologic aspect of the cardiovascular pedicle. These contributions have cleared up many errors of grave importance, carefully handed down in all the works of roentgenology, proving by means of experimental and clinical facts that the image of the vena cava is visible in the normal subject, and that the cylindrical shadow seen to descend (the patient being observed in the right anterior oblique position) down the clear retrocardiac space parallel to the ascending aorta, which was believed and is still thought by many roentgenologists to be the shadow corresponding to the descending portion of the aorta, is not this vessel at all but the superior vena cava.

They have also conclusively proven that the extent of the roentgenoscopic shadow of the descending aorta is very far from being that which it was formerly thought to be, in open contradiction to the classical teachings

of descriptive anatomy; but on the contrary, according to their teachings, it crosses in an oblique direction from before backwards the clear retrocardiac space, and at the level of the body of the fourth dorsal vertebra turns and descends along the left side of the spine. These observations have been later confirmed by these authors' most interesting studies on the senile aorta and by the recent and most conclusive experiments of Thoyer Rozat.

On the other hand, on account of the deep location of this segment of the vessel in the posterior mediastinum, and the considerable distance from the fluoroscopic screen, its image is not visible in the normal subject, because its shadow, weakly opaque, is lost among the clear projections from the pulmonary parenchyma and the large bronchi, and those transparent organs located behind the retrocardiac space. It is only when the aortic opacity is augmented through some pathological or senile lesion or when the clear transparency of the lungs is considerably diminished, that favorable conditions obtain for the perception of the shadow.

Starting with these precise conceptions, it has been possible to perfect the technique and to enrich our stock of knowledge of roentgenoscopic symptoms of diseases of the cardiac pedicle; for precise roentgenoscopy enables us to make simultaneously the volumetric and qualitative analysis of the large trunks which compose it, and even in some occasions of its efferent branches.

The volumetric analysis is practiced by measuring the caliber of the vessel, and, in the case of the aorta, calculating also the transverse diameter, the cord of the so-called hemicircle, or the left superior arch of the middle shadow, and the height of the aortic bend.

The caliber of the aorta, which varies with the age and build of the subject, is measured over its ascending portion, between the bend and the salient of the pulmonary artery, ranges from 10 to 20 millimeters at sixteen years of age and between 30 and 35 millimeters at sixty.

It is a dimension of the greatest clinical value when it has been carefully and accurately calculated. That is why it is important to measure it, confining oneself strictly to the rules of orthogonal projections; that is, tracing the normal ray tangentially to each one of its borders. To accomplish this, the most favorable position is the right anterior oblique, employing the x-rays at an approximate incidence of 35 degrees. The exactness of the obtained measurement taken must be verified by estimating again the caliber of the artery in the left antero-oblique position.

We must call attention to an error frequently made while taking this measurement. This error consists in trying to separate, with the subject in the right anterior oblique position, the shadow of the vessels from that projected by the vertebral column, by a clear space which is quite conspicuous, and while keeping the central ray in a fixed position, measuring the pedicular shadow from its anterior mediastinal border to the posterior border. Vaquez and Bordet have shown that this measure, given as that of the aorta, is not at all correct, as it includes that of the artery and part of the vena cava.

The transverse diameter of the normal aorta varies according to age, between 4 and 8 centimeters; the chord of the aortic hemicircle, from 0 to 4 centimeters. The upper border of the arch of the aorta is about 2 centimeters below the lower border of the left clavicle.

The most convenient positions for the examination of the vascular pedicle of the heart are the right anterior oblique, the left anterior oblique and the right posterior oblique. The first of these is most convenient for the examination of the ascending and descending portions of the aorta, as well as the vena cava; the second is appropriate for the examination of the transverse portion of the aorta to measure in certain cases the caliber of the pulmonary artery, and for the study of certain lesions of the venous and arterial brachiocephalic trunks, as well as the left common carotid and the left subclavian arteries; and the third one is useful for the study of the anteroposterior segment in its

terminal portion and also of the arterial brachiocephalic trunk.

There is an abnormal increase of a diameter or dimension whenever its value exceeds the normal by 5 millimeters.

The qualitative analysis of the vascular pedicle can show us the degree of density of the arterial walls, according to the more or less marked opacity to the x-rays; it also gives us information about the localization and character of the beats, of the greater or lesser elasticity of the arterial walls, about the enlargement and development of the aortic arch, and about any irregularity and deformity in the outline.

From the roentgenological point of view, the most important lesions which the study of the vascular pedicle of the heart offers, are aortitis and aortic aneurysm, dilatations and aneurysms of the pulmonary artery, dilatations of the vena cava and its tributary branches, and the aneurysms of the brachiocephalic trunk and of the subclavian and left common carotid arteries.

Vaquez and Bordet recognize two varieties of aortitis: (a) Those which show signs of dilatation of the vessel, easily diagnosed by the exact measurement of its caliber. (b) Those which manifest themselves by the darkness or opacity of its walls. Although in these last the artery preserves its normal caliber, it nevertheless frequently presents an enlargement of its transverse diameter, together with diminution or even obliteration of its true pulsations, and exaggerations or tortuosity and elevation of the arch.

The aneurysmal dilatations present a syndrome which is defined through the volumetric and qualitative study of its roentgenologic image, whose great axis, as well as the direction of its pulsation, will be directed according to their anatomic position and that at which the patient is being examined, to one or the other side of the median shadow if studied in the frontal position, and towards the thorax or vertebral column in an oblique position.

Vaquez and Bordet synthetize by means of the following formulae, which give a precise diagnosis, the direction most commonly followed by the salient in aneurysms of the aorta.

The aneurysms of the ascending portion of the aorta, if the sac is lateral, project, when viewed from the front, towards the right of the median shadow, and when seen in an oblique direction, towards the vertebral column, if viewed right anteriorly; and towards the thorax, if seen left anteriorly. If the sac is anterior the shadow projects constantly towards the thoracic wall and towards the vertebral column if posterior.

Aneurysms of the descending portion, when in a lateral situation, project their images towards the left, towards the thoracic wall and towards the vertebral column, respectively; when the sac is anterior, towards the thorax in the right anterior oblique position and towards the vertebral column, in the left anterior oblique; and if the sac is posterior it is invariably directed towards the vertebral column.

Aneurysms of the transverse portion of the aorta grow as a rule in a vertical direction.

As to the pulmonary artery, the study of deformities and qualitative modifications in the median arch leads with fairly good precision to the diagnosis of any dilatation, a complication so commonly found in cases of pulmonary insufficiency or stenosis. It is also at the same time possible to discover any sclerotic or atheromatous degeneration.

Dilatations of the superior vena cava, whether caused by mechanical compression from intrathoracic tumors, inflammatory process of the mediastinum, or secondary to incompetency of the right cardiac orifices, can also be diagnosed.

Exact roentgenology, the roentgenology of precision, in a word, owing to the more correct interpretation of fluoroscopic images, due to the most interesting investigations of Vaquez and Bordet, and of Thoyer Rozat, and thanks also to the recent perfections of their methods of examination, is to-day capable of solving with far more precision than any of the old clinical procedures the diagnosis of the different morbid processes of the heart and its vascular pedicle.

TUMORS OF NERVE TISSUE IN RELATION TO TREATMENT BY RADIATION*

By JAMES EWING, M.D.

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REGARDLESS of its future as a therapeutic agent, one of the permanent contributions of radium therapy has been the demonstration of certain biological properties of malignant tumors which were previously unrecognized.

Basal cell carcinoma, in whatever one of its many forms it may appear, is regularly susceptible to radium, while squamous carcinoma is comparatively insusceptible. One could hardly anticipate that lymphosarcoma, which grows rapidly and invades tissues with destructive disregard, should melt away with surprising promptness under gamma rays. These differences, revealed by the reaction to radium, have elucidated other peculiarities in the biology of these tumors.

In general, the structural characters which determine susceptibility to radiation are a cellular character; an undifferentiated form of the cells; rapid growth with abundance of mitoses; vascularity, especially when due to abundance of delicate capillaries; and absence of much intercellular substance. On the other hand, tumors prove relatively insusceptible when the cells are differentiated and adult in type; when they grow slowly and mitoses are few; when the blood supply is through well formed adult vessels; and when there is much intercellular substance.

Considering the tumors that affect nerve tissue, in brain, meninges, spinal cord, and peripheral nerve trunks, one finds very wide variations in the above particulars, and if the rules hold, then one should expect similar variations in the response to radium.

In the peripheral nerve trunks the structure presents in the well-known *neurofibroma* or neurosarcoma several features of the resistant tumor. The cells are large or small spindles, not overnumerous, dividing slowly in accordance with the usual clinical course; and accompanied with much peculiar intercellular substance or even with definitely formed although imperfect fibrillar structures; while the blood supply is moderate with well formed blood-vessels of the type of arterioles. Accordingly one finds that this tumor is exceedingly resistant to all forms of radiation in any dosage that can safely be applied through the skin.

It is highly unfortunate that this common tumor should enjoy such resistance to radiation, for it is especially prone to recur after excision and to assume more malignant tendencies after each operation.

The dangerous character of this disease seems to deserve special emphasis, for at the Memorial Hospital during the past two years there have been received more than 100 recurrent cases of this type, in which from one to twenty-one operations had been performed. The persistence of these recurrences is quite remarkable. Even after wide excision, the neighboring tissues seem to join forces in providing new tumor tissue, as though the nerve filaments on all sides of the growth had the capacity to excite growth of neoplastic cells, after the manner in which the primitive neuroblasts are said to provide themselves with sheaths from the tissues in which they travel. Or the recurrent tumor may develop anew in an adjoining segment of the affected nerve trunk, which in many cases is condemned to tumor growth throughout much of its extent.

Most of these tumors pass unrecognized and fall in the general designation 'sarcoma.' Yet the structure of intertwining fibrils and long spindle cells is quite specific and easily recognized. They are quite different in reaction to radium from the soft and vascular fascial sarcomas.

The exact form in which these dangerous

* Read before the New York Neurological Society, New York Academy of Medicine, Dec. 7, 1920.

tumors first appear is not entirely clear, but many of them are regarded as innocent movable tumors of the subcutaneous tissue or intermuscular planes. In attacking such a tumor the surgeon should realize that he is undertaking a very serious problem and that if operation is not successful he can expect little aid from physical agents. Neurofibroma of the acoustic nerve has a generally unfavorable prognosis, but there is a myxoglioma of the optic nerve occurring in young subjects, which is readily enucleable and does not recur.

Endothelioma.—There are several different structural types of tumors of brain, cord, and meninges which are commonly referred to an endothelial origin.

Psammoma, or sand tumor, is a frequent, well-known, slowly growing, hard, single or multiple tumor of the meninges, affecting either brain or cord, and sometimes extending all over the cerebrospinal meninges. It is composed of dense concentric masses of meningeal lining cells, and arises from the so-called endothelial buds of the dura mater. It does not seem possible that radiation can have more than a mild inhibiting influence on such a tissue, unless radium is applied directly to the tumor or inserted within it. Since they are usually located in the dura, this mode of treatment should often be possible.

Rarely one encounters vascular and cellular endotheliomas which may be more susceptible; but whenever the cells are of adult endothelial type and of pavement form, they cannot be regarded as a very favorable type for treatment by radiation, unless radium can be inserted within the tumor.

True angio-endothelioma, or perithelioma, occurs in the meninges and substance of brain and cord, as well as along the peripheral nerve trunks as they emerge from the cord in the spinal canal. These tumors are composed of large polyhedral or cubical, occasionally flattened cells, surrounding blood channels. Groups of such cells occur in the rare diffuse sarcoma of spinal meninges. They should be more susceptible to radium.

Angiosarcoma is the common tumor of the sarcomatous class that occurs in the brain. It appears to arise from the cells composing the blood-vessels, and is one of the few examples of a true mesoblastic sarcoma arising from blood-vessels. It grows rapidly; often reaches large dimensions; is generally encapsulated as contrasted with glioma; and it is soft, highly vascular, and subject to hemorrhages. It is one of the few tumors that has been satisfactorily traced to a traumatic origin.

As far as the tissue itself is concerned this tumor ought to be markedly influenced by radiation, since its nutrition is very unstable; but whether a slow and safe regression can be accomplished appears doubtful, especially with bulky tumors. On the other hand very few successful surgical removals of such growths have ever been accomplished, so that they are legitimate territory for experimentation with physical agents.

Glioma.—Of all tumors of brain and spinal cord, glioma in its various forms presents most of the structural features that favor susceptibility to radiation. They are cellular, sometimes extremely so; the cells are of delicate construction and labile chemical constitution, which render them very prone to autolysis and liquefaction; the blood-vessels are numerous and very fragile, and the tumors are notably subject to hemorrhage and necrosis. They are by far the most frequent brain tumór, forming 55 per cent of all tumors, including fibromas, cysts, and tubercle. (Tooth.) They are chiefly cortical, and their sites of election are the cerebellum and the frontal lobes. Unfavorable features are their comparatively rapid growth, lack of encapsulation and the secondary effects on surrounding brain tissue.

Three main types of glioma may be recognized: Astrocytoma, typical adult glioma with glia cells and fibrils; Gliosarcoma, which is anaplastic and very cellular; and Neuro-epithelioma, which is the embryonal form. Only the astrocytoma contains anything like a resistant intercellular material, and this is usually poorly formed and scanty. Extravasated blood and cystic collections of fluid form a considerable portion of the

bulk of many gliomas, and are quite as effective in producing pressure as growing tumor cells.

On the whole I know of no tumor which on *a priori* grounds ought to yield more readily to moderate radiation than the average glioma.

Primary *carcinoma* of the brain arises from the lining cells of the choroid plexus. Although originally derived from neuroblasts these lining cells have acquired the properties of lining epithelium. The resulting tumors take the embryonal type of ependymal glioma, or more frequently the adult type of papillary adenocarcinoma. These adenocarcinomas occupy the lateral *ventricle*, seldom reach dimensions exceeding 4 to 5 cm. in diameter, and they are composed of very delicate mucinous stroma supporting fragile capillaries and lined by coherent masses of small delicate polyhedral cells. The growth is slow. Their structure indicates a high degree of susceptibility to radium. More coarsely built adult papillary adenocarcinomas occur which seem to arise from the velum interpositum.

In the region of the third ventricle project the very delicately structured cellular tumors of the pineal gland. In the fourth ventricle are found chiefly gliomas and angiomas, the latter quite beyond the reach of either knife or physical agent. From this region I have recently seen a papillary neuroepithelioma of very delicate and vascular structure. The patient succumbed to exploratory operation.

All these tumors along the center of the brain axis are well protected by distance from the attack by radiation, but their very delicate structure encourages the hope that they may in some instances be favorably influenced by the physical agents.

The group of *hypophyseal tumors* includes cysts, chronic adenomatoid hyperplasia, cellular adenocarcinoma, glioma, and hypophyseal duct tumors.

There are no data suggesting that radium can affect the accumulation of fluid in the cysts.

Chronic hypophyseal struma with acromegaly has already been definitely influenced by x-rays directed through the temporal regions. Béclère's results, especially, encourage the effort to control these partial tumor processes by the physical agents and to devise more direct means of access to them by surgery. Quick has already reported on the efforts made in this field at the Memorial Hospital, and it is our belief that success will eventually be attained by exposing these tumors for direct radiation or by inserting minute quantities of radium within them. It cannot be said that hypophyseal struma, being a form of functional hyperplasia, is very susceptible to radiation. The cellular adenocarcinomas are more so. In either case the bulk of the tumor should render the insertion of radium a safe procedure, if infection can be avoided.

The hypophyseal duct tumors belong in the class of basal cell carcinomas of the salivary gland type. In the salivary glands these tumors respond well to radium but regression is very slow. In the hypophysis the tumors are usually cystic.

The slow course of most hypophyseal growths and the peculiar clinical symptoms due to functional disturbance of the endocrine system provide very delicate indicators of any therapeutic effect that may be produced upon them, and render this field of unusual interest in radium therapy.

The possibility of applying radium successfully and safely to intracranial and intraspinal tumors depends on several factors. Chief among these is the obstacle presented by the skull. In the adult the average thickness of the skull is about 5 to 6 millimeters. This thickness of bone tissue, it has been found, will absorb between 2 per cent and 3 per cent of the gamma rays which pass through 2 millimeters of brass. Accordingly the dosage would have to be increased to meet this loss, if one is to deliver a radiation known to be effective with other more exposed tumors. Yet this result can be accomplished by increasing the quantity of radium used, as well as the distance and time factors, but it must be recognized that an additional difficulty exists which is not en-

countered with other less protected tumors.

The distance of many tumors from the scalp, especially those lying centrally, or at the base of the brain, is an even greater handicap than the absorption by the skull, for the radiation diminishes as the square of the distance. To meet this difficulty a further increase in dosage, distance and time must be provided. Hence it would appear that the effective treatment of brain tumors by external radiation will require so much radium as to restrict this method to institutions possessing large amounts. Since only cellular tumors can be definitely influenced by heavily filtered radium at a distance, the method is still further limited to such types, which are mainly the gliomas, and cellular tumors of neuro-epithelium and ependymal cells.

In children, the comparative thinness of the skull, smaller size of brain, and more frequent occurrence of cellular tumors suggests that external radiation should first be employed before proceeding to other methods.

That an effective dosage of radiation can be delivered through the adult skull to all portions of the brain, sufficient to influence the growth of cellular tumors, can be shown by physical computation, and has been demonstrated experimentally by the work of Dr. Bagg on dogs and monkeys. Whether such dosage will prove sufficient to bring to a standstill or to definite regression any of these tumors, can be determined only by actual experiment on the human subject. It is sufficient to point out that the use of radium in such cases, is not a mere placebo.

Two thousand millicuries of emanation filtered through 2 mm. of brass and placed for six hours at a distance of 6 to 10 cm. from the skin, has often produced rapid regression of deep glandular carcinomas, metastases of testicular carcinoma in the epigastric region, and retroperitoneal lymphosarcoma. A reduction of 10 per cent for the absorption by the skull and brain can readily be met by increasing either dosage or time. The hair of the scalp will be sacrificed, but the cuticle need not be injured. Nor has such dosage produced definite subjective cerebral symptoms during its application or afterwards.

In the brains of normal dogs and monkeys these dosages have not, in Bagg's observations, produced any structural changes, or any demonstrable symptoms. In fact it appears that very much higher dosage, resulting in a caustic necrosis of the scalp, may be tolerated without yielding structural changes in the normal brain. It has been upon this experimental evidence that we have felt justified in employing large dosage over the brain in subjects suffering from brain tumors, and the cases exhibited this evening, which have been thus treated, confirm our conclusions regarding the safety of the dosage.

But the brains of subjects of intracranial tumors are not as a rule normal. Especially with actively growing vascular gliomas and sarcomas, and even with slowly growing localized endotheliomas, as shown by Collier, the circulation of the brain is often disturbed, and acute or chronic edema may affect a large portion or the whole of one hemisphere, giving rise to many peculiar secondary symptoms. General intracranial pressure is often at the upper limit of safety or even beyond it, with all types of intracranial growths. Flattening of the convolutions, capillary anemia, ventricular hydrops, miliary hemorrhages, and exudative and degenerative changes, are some of the anatomical conditions that may complicate the tumor. In twenty of twenty-nine cases, mostly of cerebellar tumors, Batten and Collier found that distention of the spinal arachnoid had produced degeneration of the posterior columns and ganglia, with stretching, tearing, and compression of the nerve roots.

Under such conditions the effects of radium application may be quite different from those observed in normal brains and cords. Full radium dosage may be expected to produce hyperemia, increase of intracranial pressure, and probably some edema, before it can cause any definite recession in the bulk of a tumor. Therefore, unless the patient can withstand a certain temporary increase in

pressure, the application of radium may be followed by aggravated symptoms.

When the tumor can be exposed, it becomes accessible to direct application of radium, or to the insertion of emanation needles. The last method is undoubtedly the most effective in dealing with the tumor, without regard to its structure, but it is accompanied by the danger of infection, and the risk of damaging normal brain tissue. Tissues affected by radium are undoubtedly more susceptible to infection than normal tissues, but one can hardly question the capacity of modern surgical technique to cope with this matter. As for the damage to normal brain tissue, Bagg's experiments show a remarkably uniform and sharply demarcated zone beyond which the effects of radium on normal brain tissue are negligible. If radium needles are to be used it is highly important that the tumor tissue should not be disturbed by partial excision, as the tumor tissue acts as a filter protecting the normal unaffected areas.

The practice of attempting to remove as much as possible of the tumor and then turning the case over for radium treatment generally assures a failure and discredits radium therapy. With few exceptions, if a brain tumor is to be treated by radium, surgery should be used only to expose the tumor. A cordial cooperation and mutual understanding between surgeon and radiologist are essential if any success is to be achieved in this field.

Any attempt to suggest the scope and limitations of radium therapy of brain tumors, on theoretical grounds, is obviously surrounded by so many possibilities of error, that the undertaking may well prove useless or even presumptuous. In nearly all respects the problem is a clinical research, to be undertaken by the experienced neurological surgeon and the radium expert, and the only safe guide is experience. If there is any justification for the discussion presented in the present paper, it is found in the review of those invariable actions of radium which have been observed in other fields, and the analysis of the structure of brain tumors as they are found to occur. Without this knowledge as a basis the neurological surgeon, and the radiologist as well, are helpless in attempting to form an estimate of the indications for radium in this field, or in judging of its results.

SYPHILIS OF THE LUNGS, ITS RADIOGRAPHIC FINDINGS AND THEIR PATHOLOGIC BASIS*

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SYPHILITIC infection of the lung is not a common disease, but that it does occur and that it is mistaken for other pulmonary diseases there can be little doubt. The diagnosis is difficult, particularly in the earlier stages. Most of the modern writers mention the roentgen ray method of examination as being of assistance; and if there are appearances suggestive of syphilis of the lung on the *x*-ray plate, their recognition is certainly of vast importance to the occasional sufferer from this affliction, especially in the differentiation of pulmonary tuberculosis, because a correct diagnosis means specific treatment and relief.

Pneumonia alba fetalis is universally recognized and will not be considered in this discussion.

Incidence.—At a luncheon table recently, a pathologist and a surgeon were sitting side by side. The subject of syphilis of the lung came up. The pathologist remarked: "Syphilis of the lung has never been proven to exist." "Certainly it exists," said the surgeon; "I can show you a case." Thus is defined two points of view, the ultra-scientific and the clinical. Those looking at the question from the clinical side are hoping that histological technique may be improved so that incontrovertible proof may be furnished by the demonstration of the treponema pallidum in pulmonary lesions as it has been in the aorta and brain.

Osler[1] refers to pulmonary syphilis as a "very rare disease." In 2,800 autopsies at the Johns Hopkins Hospital, there were 12 cases, in 11 of which there were definite gummata. Two were suspected clinically. Fowler could find only 12 specimens in the museums of London, two of which were doubtful. Lord[2] states that among 3,000 autopsies at the Massachusetts General Hospital, there was one case with syphilitic ulceration of the trachea and indurative pneumonia with cavity formation. The syphilitic nature of the pulmonary lesions was considered doubtful. Carrera[3] recently made a pathological study of the lungs in 152 autopsy cases of syphilis. Among these he found 12, or 8 per cent, which he believes show unmistakable evidences of syphilis. Osler remarks that the pathological diagnosis depends a good deal on the conception of the individual pathologist as to what constitutes a syphilitic lesion.

From the clinical side, McCrae and Funk[4] found in 1200 cases referred to the Jefferson Chest Hospital as being unquestionably tuberculous, 72 which were non-tuberculous, of which number 4 had pulmonary syphilis. On the other hand, Carrera quotes Otis as having stated that in his experience he had not found a case which he believed to be syphilis of the lung. Post[5] reported two cases in 1916 which he believed to be syphilis of the lung. One of these has since returned to the Massachusetts General Hospital and will be discussed below. In the wards of the Massachusetts General Hospital 5 diagnoses of syphilis of the lungs have been made, all since 1908, and two of them are followed by a question mark. Two of these diagnoses involved the same case on two admissions eleven years apart.

Watkins,[6] who has been particularly interested in this question from a roentgenological point of view, reports that out of 5,000 *x*-ray examinations of the heart and lungs, 146 cases, approximately 3 per cent, were diagnosed, positively, or probably, as uncomplicated lung syphilis and 68 cases as combined tuberculosis and syphilis. He believes the latter figure is far below the actual incidence of this combination.

*Read before the New England Roentgen Ray Society, April 2, 1921.

Pathology.—In the interpretation of radiographs, we attempt to read the shadows representing the various degrees of density in the part through which the rays have passed in terms of pathology. In the discussion of this subject, it may be of advantage to reason the other way around, that is, from pathology to the shadows which might be expected on the x-ray plate. A valuable review of the literature from the pathological point of view has been published recently by Carrera[3] along with his report of the study of the lungs in 152 cases of syphilis. From this and other articles the following points which might be of importance from the x-ray standpoint, are taken.

Two chief types of lesions have been described: the gumma, and fibrosis or chronic interstitial pneumonia.

Cases of gumma of the lungs have been described by many writers. Some of the points emphasized as characteristic are: the multiple occurrence of the gumma; its subcommitant pleural thickening; and the extraordinary cicatrization of the lesion. Most writers say that a gumma rarely appears in the apex, and all agree that the right lung is more frequently affected.

The characteristics described as typical of chronic interstitial pneumonia or sclerosis are as follows: Diffuse infiltration localized in the middle or lower portions of the lung with sclerosis of the bronchi which may be dilated. Sclerotic tissue radiates from the hilum or from the pleura, may extend to the farthest zones of the lungs and may give to the lung a lobulated appearance. Around the bronchi and vessels, the thickening is constantly found, and in some places the alveolar walls are thickened. All writers agree that bundles of connective tissue radiate from the pleura, in many cases crossing the lung from side to side. Pye-Smith[7] regards peribronchial gummas or plaques as the starting point of the process and the bronchiectasis as the result. Roessle[7] states that the characteristic changes in chronic interstitial pneumonia are peribronchitis and periangitis, thickening of the alveolar walls and new formation of a network of connective tissue. The lesion affects chiefly the lower lobes. No secondary collapse of the lung takes place.

Syphilitic lesions of the pleura were believed by the older authors to exist. Sadowski[7] saw a case of gumma of the pleura. Raymond[7] accepted the existence of an exudative syphilitic pleuritis. Hamman[8] states that in chronic cases of pulmonary syphilis the pleura is often involved and great thickening of this tissue may accentuate the pulmonary sclerosis. Carrera in his own cases found that old pleuritic adhesions and thickenings were common, but the changes could not be identified as characteristic of syphilis. Schupfer[9] reported a case of pleuritic involvement which subsided under antisyphilitic treatment, but believes that this and the majority of cases in the literature are of tuberculous origin. His opinion is apparently based, in part at least, upon the fact that he has traced many of the cases of supposed syphilitic pleurisy and has found that they developed frank tuberculosis later. The writer recently observed over a period of months a case (to be reported elsewhere) which came to the hospital with a rapidly recurring hydrothorax, the fluid being of the exudative type and sterile. Guinea pig innoculation gave a negative result. The effusion quickly cleared up under antisyphilitic treatment and the patient has gained weight and has been about her work for over six months. The burden of proof would seem to be upon him who states that in such a case the pleurisy was of tuberculous origin. A patient having had a syphilitic pleurisy might develop active tuberculosis later.

Hamman[8] remarks that syphilis is common in the upper respiratory passages and rare in the lungs, while the opposite is true of tuberculosis. The point of bifurcation of the trachea is a favorite location of syphilitic ulceration. As the lesion heals contraction occurs and one of the main bronchi may become occluded, resulting in extreme bronchiectasis and fibrosis. Lord[2] calls attention to the fact that in cases in which tracheobronchial syphilis is present, bronchostenosis may give rise to inflammatory and indura-

tive changes in the pulmonary territory supplied by the stenotic bronchus without actual invasion of lung tissue by the syphilitic virus. According to Carrera, the occurrence of syphilitic thickening of the bronchi has been emphasized by many writers and many have ascribed a syphilitic origin to bronchiectasis. Osler and Gibson[7] state that bronchiectatic cavities may be associated with a syphilitic pneumonic process, and that a lung may be excavated by a bronchial dilatation in the same way as from an aneurysm. Nodal[10] remarks that the pulmonary scleroses in congenital syphilitic children involve to a variable degree the pleurae and the lungs. They are invariably accompanied by bronchiectasis. The condition is often misinterpreted as cavernous tuberculosis, pneumonia, pleurisy or simple bronchitis.

Carrera divides his cases into two classes: (1) Gumma with peribronchial lesions and arteritis. (2) Fibrosis and arteritis.

Syphilitic fibrosis takes its inception, he states, in a typical inflammatory process due to the local action of the spirochetes, and is the termination of the syphilitic process. It should extend along the vessels and bronchi as well. He also studied connective tissue formation in 60 cases of tuberculosis and is convinced that it is never impossible to distinguish the two. The scar of the tubercle is round, sharply delimited, more frequently calcified and often very confluent or conglomerated. The scar of syphilis is irregularly radiating or stellate and not sharply delimited. The scars of gummas are extremely rarely conglomerated or confluent. The syphilitic fibrosis begins under the pleura and around the bronchi and is more frequently anthracosed and very rarely calcified. He does not discuss the gross distribution of the lesions in these cases.

The Radiograph.— It is evident from the foregoing that the possibilities for variation in individual cases of syphilis of the lung are manifold, and that it would be difficult to make a satisfactory classification from the *x*-ray standpoint. However, in view of the pathology of this condition, three different types might be expected; two corresponding to Carrera's two types, i.e., (1) gumma with peribronchitis, and (2) fibrosis; and the third resulting from bronchostenosis with or without actual parenchymal involvement. The pathological descriptions are definite and their relations to the shadows on the *x*-ray plate are more or less self-evident. A few points in connection with each type may be worth mentioning. The frequency with which pleural involvement has been found should be borne in mind.

1. *Gumma with Peribronchitis.*—This type, of course, would vary with the progress of the disease. In its early stages it would show bronchial markings with small knobby enlargements due to small peribronchial gummata. Figure 2 is an example. Later the picture would be modified by the increase in numbers and size of the gummata, by scar formation resulting in linear shadows radiating from hilus or pleura with contraction of the lung and retraction of the mediastinal contents, and by increasing pleural involvement. Figure 3, the same case as Figure 2 but five years later, is an example. The process develops from the hilus outward, and it is the consensus of opinion that it prefers the lower portions of the lung. It tends to develop extensively in one lung, which is more apt to be the right according to the literature, leaving the other relatively clear, e.g., the left lung in Figure 3. The shadow of the gumma should be rather irregular in outline, poorly defined, and, when cicatrized, radiating or stellate, and rarely if ever calcified.

2. *Syphilitic Fibrosis.*—This may give a rather diffuse increase in bronchial shadows without evident gummatous enlargements, as is suggested by right lung in Figure 4.

3. *Bronchostenosis.*—The result of stenosis of a bronchus is collapse of the lung followed by extreme pathological changes. On the *x*-ray plate, there is absolute dulness involving one whole side with marked retraction of the heart and mediastinum to that side. Figure 1 and possibly Figure 4 are

examples. The same shadows might be given by the first type mentioned, gumma with peribronchitis, if the process had continued far enough.

The above discussion has been confined to the later manifestations of syphilis. The fact that there may be pulmonary signs in the secondary stage is well known. Funk[4] refers to the possibility of confusing the râles which may be present in the apices in patients with secondary syphilis with those of early tuberculosis. Dunham[11] describes a case with luetic mucous lesions of the mouth, which showed diminished excursion of the diaphragm on the right side and prolonged expiration with fine dry and subcrepitant râles in the right upper chest. The plates showed nothing abnormal. The physical signs cleared up after one dose of salvarsan. He remarks that although the "syphilitic catarrh" may give physical signs which minutely simulate those of early tuberculosis, it leaves no record on the *x*-ray plate, a fact of some importance in differential diagnosis.

Diagnosis.—The diagnosis must depend on all the facts available from the history, physical examination and laboratory findings. The affinity of tuberculosis for the upper part of the lungs and its tendency to be bilateral are well known. Resolving or unresolved pneumonia, malignancy[12] and massive collapse of the lung of traumatic origin, must be borne in mind, as they may cast shadows indistinguishable from those of lung syphilis. A case was recently seen in this laboratory which showed homogeneous dulness throughout the left chest with marked retraction of the heart to that side, suggesting collapse of the lung. Syphilis of the lung was mentioned as a possibility to be considered. The patient, however, had a history of trauma, a fall from a wagon, from which his symptoms dated. Re-examination a few days later showed a hydropneumothorax, ruling out the possibility of lung syphilis and favoring massive traumatic collapse of the lung.[13] Dr. Post[5] mentions a case in which *x*-ray examination showed one whole side to be dull and which at autopsy was found to be malignant. The roentgenologist will certainly be of great service if he does nothing more in suspicious cases than to direct attention to the possibility of syphilitic involvement of the lungs.

In summary, the following points may be worthy of mention. When syphilis attacks the lungs, it prefers the lower part, seldom involving the apex. The process is apt to be more marked around the hilus, progressing from this part of the lung along the bronchi toward the periphery. It tends to develop unilaterally and may completely destroy the function of one lung, involving the other comparatively little or not at all. It involves the pleura extensively and causes a marked connective tissue reaction, producing radiating or stellate scars which may be very extensive and which calcify rarely. Three general types of roentgenogram may be expected, based upon three ways in which this condition may develop pathologically:

1. Gummata with syphilitic peribronchial infiltration.
2. Syphilitic peribronchial fibrosis.
3. Bronchostenosis with collapse of the lung, resulting from syphilitic ulceration of a bronchus.

The following cases are appended as illustrative. Nos. I and II are, from the clinical standpoint, quite certainly syphilis of the lungs. In Case III, this diagnosis is very probable, but the patient was not observed long enough to make it certain.

CASES

Case I (Fig. 1). M. Female, age twenty-five years. Father had locomotor ataxia. One brother, age twenty-nine, living and well. Three sisters born next died in early infancy. Two children stillborn. Tuberculosis in aunts and uncles on both sides.

Infantile paralysis at six affecting the left side. Pneumonia at six. Diphtheria at thirteen. Has been in a hospital four times for "chest trouble," the last time in 1911. Was a patient in a State tuberculosis hospital for ten months in 1910–11. A report from

that institution gives the following facts: "Rough breathing and a few râles at the tops of both lungs. Sputum examination repeatedly negative. Temperature 96.8–99.4 degrees. Pulse 80–100. Record does not indicate any material change in physical signs during stay in hospital. Gained 6 pounds in weight and was discharged as improved. No *x*-ray was taken." In 1912 patient went to the Eye and Ear Infirmary with interstitial keratitis. In 1913 she was given two injections of old salvarsan at the Boston Dispensary. In 1914 she was admitted to the Massachusetts General Hospital complaining of pain in the left hip. Physical examination at that time gave the following facts: Small, deformed, decidedly deaf. Ground-glass appearance to cornea. Pupils irregular but react to light and distance. Radiating scars at corners of mouth. Scaphoid scapulae, clavicles short. Left chest smaller than the right with little respiratory motion. Over the left front and back dulness and increased breath and voice sounds. Few dry râles. Over left back a marked rub was heard synchronous with the heart beat. "Cracked pot" sound at the left base behind. Heart: Apex was felt in the fifth space 15 cm. to the left of midsternal line. Spleen just palpable. Peroneal group of muscles atrophied on the left leg. Luetin reaction positive. Temperature normal. *X*-ray report: "The left chest is dull throughout, more dense at base. Heart and trachea are displaced to the left. There is apparently very little sound lung tissue on the left side. Right chest negative. Extensive chronic process involving the left side of the chest, probably not tuberculosis, may be syphilis."

FIG. 1. CASE I. Diffuse dulness throughout the left chest, obliterating the outlines of the heart and diaphragm. Marked retraction of the heart and mediastinal contents toward the affected side. The right lung field is clear. Bronchostenosis with collapse of the left lung. This case was reported by Dr. Abner Post in 1916. A comparison of this plate with the one published at that time shows no change in the appearance of the chest.

In December, 1920, she reappeared at the Out-Patient Department, complaining of cough and shortness of breath on exertion, and was admitted to the Hospital. She was totally blind and was deaf to all but the loudest sounds. For the previous two months there had been increasing urinary frequency and some incontinence. Examination of the chest showed signs on the left side about as in 1914, except there were many râles. The right chest showed dulness above the second rib, and diminished breath sounds throughout. Apex of the heart was not felt. Blood Pressure, 122-78. No clubbed fingers. Urine negative. White count, 14,000, 16,000. Provocative Wassermann negative. Spinal fluid negative. Eye consultant: "—Sure that the eye represents some form of lues." Ear consultant: "—Marked nerve deafness. Probably specific." *X*-ray, December, 30, 1920: "Appearance is practically the same as described in 1914. The entire left side is dull. Heart and mediastinal contents are displaced to the left. Trachea can be seen to the left of the spinal column. The appearance is that of an extensive destructive process involving the left lung. Lues should be considered." Temperature normal except on two occasions when it reached 100°. Discharge diagnosis: Old anterior poliomyelitis. Congenital syphilis. Fibrosis left lung, (?) syphilitic.

Discussion.—This case was the second of the two reported by Dr. Post in 1916. A comparison of the plate taken in 1920 with

the one made in 1914 and published in his article shows absolutely no change in the appearance of the chest. It represents the type which we believe is due primarily to bronchostenosis, although actual syphilitic invasion of the lung may be associated. Unfortunately, data as to antispecific treatment is not at hand. Probably, in a case as far advanced as this with such extensive cicatrization, little change in the x-ray plate would be seen as the result of antiluetic medication, although clinical improvement might be marked. In Dr. Post's first case, the only change in the picture three years after beginning treatment was a diminution in density over a small area at the level of the first interspace, yet this patient was doing his daily work and was "passing among his friends as a healthy man."

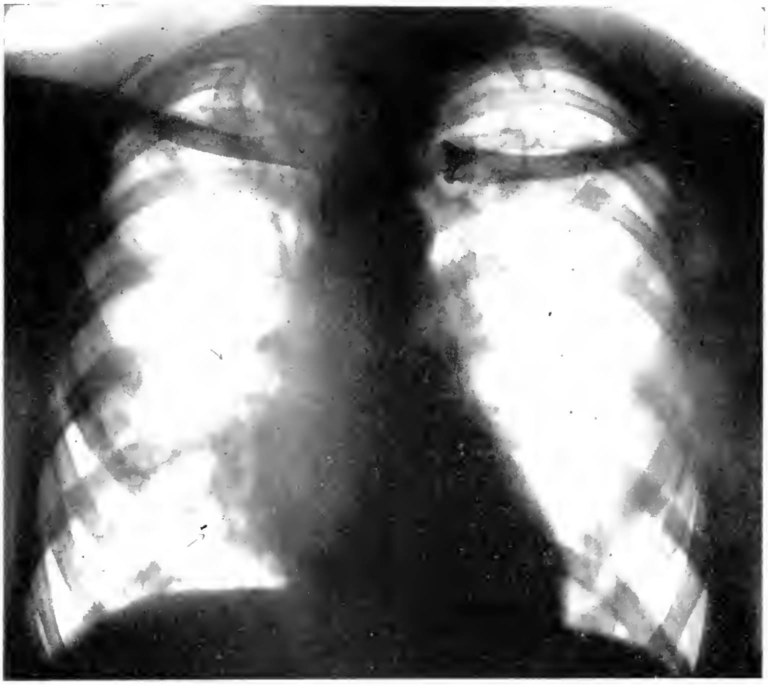

FIG. 2. CASE II (1914). Marked thickening and irregular coarse beading of the bronchial shadows. Mottled dulness along the right lung margin. Dense shadows about the right hilus extending down nearly to the diaphragm. Gummata with peribronchitis at a relatively early stage.

CASE II (Figs. 2 and 3). G. Male, white, age forty.

Appeared at the Out-Patient Department in 1906, with a Neisser infection and secondary syphilitic lesions of the mouth and skin. The former extended to the seminal vesicles, compelling the patient to undergo a long series of treatments in the G. U. Department. The latter gradually responded to proto-iodide of mercury pills and KI. In 1908, he was admitted to the wards of the hospital complaining of a severe cough and raising about a pint of greenish purulent sputum daily. Three months and one month before admission, he raised a wineglassful of dark blood. He had no night-sweats and said that he felt well. Physical examination of the chest showed slight dulness, diminished breathing and voice sounds with occasional crackling râles at the end of deep inspiration at the right base in the axilla and behind. Elsewhere the lungs were not remarkable. The sputum during his stay in the Hospital was small in amount and showed no tubercle bacilli or elastic fibrils. Tuberculin skin test was positive. His temperature was usually normal. Its highest point was 100.8 degrees. There was no daily variation.

His weight was 138 pounds. The diagnosis on discharge was: (?) Syphilis of the lung, (?) Tuberculosis. The x-ray report on the Out-Patient record is: "Generally negative. Apparently something in both apices. Fusiform swelling of the left clavicle." This report was apparently written into the record from memory by the clinician after a consultation over the plate with the roentgenologist, and is not a copy of the words dictated by the latter. During the succeeding year

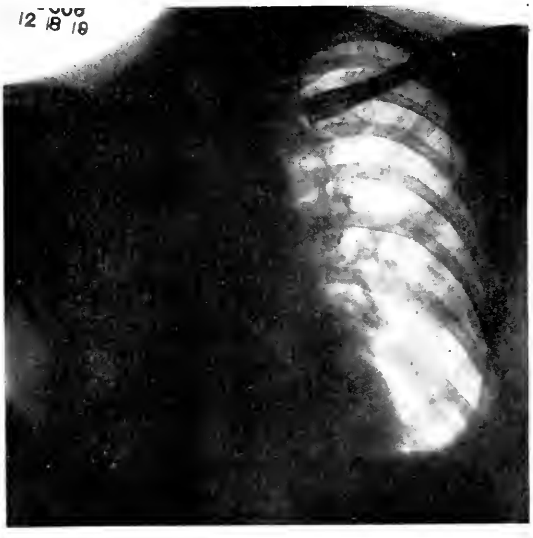

FIG. 3. CASE II (1919). Dulness over entire right chest, most dense at base, obliterating the outlines of the diaphragm and the right border of the heart. In the upper part of the dull area is a coarse mottled appearance. Heart is somewhat drawn toward the affected side. On the left the hilus shadow is increased in density and there is a diffuse peribronchial fibrosis. On the right, gummata with peribronchitis at a later stage.

after discharge the patient continued to take mercury and KI by mouth until a slight stomatitis developed. On one occasion, in 1909, his temperature was 99.7 degrees, his weight was 149 pounds and his Wassermann test was positive. He continued to cough and raise some sputum but felt quite well. In the early part of 1910, his weight was 156 pounds, a gain of 15 pounds over the weight in 1908. He was not seen in the Out-Patient Department again until the middle of 1914, when he came in with the story that he had spat up clear blood on three days of the preceding week. No tubercle bacilli were found in the sputum. X-ray examination of the chest July 28, 1914, disclosed: "Peculiar mottled dulness which appears most marked along lung margins and is scattered over the right chest and apices. Dense shadow about right hilus. Heart shadow is a little enlarged to the right. Picture is not typical of tuberculosis. May be syphilis of lungs." At this time he received three doses of salvarsan. The Wassermann was negative. During the next month he raised more bloody sputum, repeated examination of which showed no acid-fast organisms. Weight 139 pounds. Temperature 98.6°. After the fall of 1914, he was not seen again until his second admission to the Hospital in December, 1919. During this time he had no anti-syphilitic treatment. He had felt perfectly well until in October, 1919, when he was seized with a "terrible" pain in the right chest just below the nipple, worse on deep inspiration. It was diagnosed "broncho-pneumonia" by his local doctor. He was in bed ten days. For some time he had been having attacks of coughing lasting one-half to one hour in which he would raise about a half a tumbler of thick sputum, never blood-tinged or odorous. No chills, fever, or night-sweats. Physical examination of the chest gave the following facts: The left side was better developed below the clavicle than the right. The left lung was negative except for some compensatory emphysema. The right chest lagged in respiration. Below the third interspace in front and in the axilla were marked dulness and a considerable sense of resistance with diminished breathing and voice sounds. From the clavicle to the third interspace whisper, spoken voice and tactile fremitus were increased, breathing vesicular and a few fine moist râles on inspiration. The right back showed some dulness at apex increasing downward to almost flatness at base, bronchial breathing and increased whisper, spoken voice and tactile fremitus down the midscapula, below which there was diminished vesicular breathing. On cough, considerable medium moist râles were heard in the region of the spine of scapula, none at apex or base. Heart

examination disclosed nothing remarkable. All reflexes were negative. The chest consultant said: "Willing to rule out Tb. . . . Pulmonary lues the most probable diagnosis." Temperature 101.5°–100.5°. Wassermann negative. Sputum was repeated negative for tubercle bacilli, including an examination by the antiformin method. No spirochetes were found in the sputum. Urine negative. Blood: Hgb. 100 per cent (T). White count 19,600. Polys. 78 per cent. Lymphocytes 17 per cent. Large mononuclears 5 per cent. Reds normal. *X*-ray examination, December, 1919: "Entire right chest is dull. Dulness most dense at base, and outlines of the right diaphragm and the right border of the heart obliterated. In upper part of dull area there is a coarse mottled appearance, and there is a suggestion of retraction at apex. Heart is slightly drawn to the affected side. Left lung is relatively clear. Appearance is that of an extensive destructive process in or collapse of right lung and could be due to syphilis." Discharge diagnosis, syphilis of lungs. While in the ward he received one injection of diarsenol. Upon his return to the Out-Patient Department he stated that he felt much better. For a couple of months he continued to cough and again raised blood-streaked sputum in which repeated examinations disclosed no acid-fast bacilli. During the four months after discharge he received five injections of diarsenol and five of gray oil. On March 19, 1920, his weight was 130 pounds. Temperature 98.4°. He has not been seen since April 1920.

Discussion.—This, in brief, is a case observed over a period of approximately fourteen years following the appearance of secondary syphilitic lesions, during twelve of which he complained of pulmonary symptoms with occasional hemoptysis. Aside from the hemoptysis he presented none of the symptoms ordinarily associated with a progressive pulmonary tubercular infection, such as weakness, continued afternoon temperature, night-sweats and loss of weight. In the sputum, examined at intervals over a period of twelve years, acid-fast organisms were never demonstrated. There was very extensive development of the process on one side, leaving the other relatively clear, a condition very rarely seen in tuberculosis. Malignancy of the lung, of which hemoptysis may be an early symptom, is ruled out by the fact that the patient was alive twelve years following the first appearance of bloody sputum. The patient absented himself from treatment for two periods of four and five years respectively, returning both times because of renewed pulmonary symptoms and was improved both times by the resumption of antisyphilitic treatment. From the clinical point of view, the diagnosis of syphilis of the lung certainly seems reasonable.

The two plates in this case represent two stages of the gumma-with-peribronchitis type of picture. In Figure 2 there are coarse bronchial shadows with occasional small enlargements suggesting peribronchial gummata. Around the right hilus is the shadow of a larger gumma. In Figure 3 the process has progressed markedly on the right side. There has been extensive involvement of the pleura, cicatrization and retraction of the heart. In the upper part of the right lung field, coarse shadows of peribronchial infiltration and peribronchial gummata are seen. On the left there are diffuse, rather fine peribronchial shadows suggesting some fibrosis, but the lung as compared with the right is relatively clear.

Case III (Fig. 4). W. Female, white. Age forty-nine.

Came to the Out-Patient Department in October, 1915, with a series of ulcerating gummata of the skin of the right forearm. The Wassermann was strongly positive. Two months later she complained of marked dyspnea on exertion and pain in the region of the heart. There had been some cough for the preceding four to five months with scanty white sputum. No hemoptysis, fever, night-sweats or loss of weight. Physical examination disclosed dulness over the left side of the chest with broncho-vesicular breathing most marked in the axilla. Dry râles at the apex. Some moist râles on the

right side. The apex of the heart was felt 4 cm. outside the nipple. No murmurs were heard. Sent to *x*-ray with a question of syphilis of the lungs or tuberculosis. *X*-ray examination Feb. 11, 1916: "Left chest is dull throughout. Heart is displaced to the left. Right lung shows a diffuse thickening,

Fig. 4. Case III. Left chest is dull throughout, obliterating the outlines of the diaphragm and left border of the heart. Marked retraction of the heart toward the affected side. Probable syphilitic bronchostenosis with collapse of the left lung. On the right there is diffuse peribronchial fibrosis, more marked in the lower than in the upper part of the lung.

otherwise negative. Picture is very suggestive of syphilis of the lung." The patient, who had been started on mercury and KI, did not return to the hospital after this date. Thus far attempts to trace her have been unavailing.

Discussion.—This is a case of tertiary syphilis with shortness of breath on exertion and cardialgia, without symptoms which ordinarily accompany chronic pulmonary disease, as fever, night-sweats or loss of weight, pointing rather to the heart than to the lungs. Examination, however, disclosed a practically functionless left lung and a diffuse fibrosis of the right. A tubercular involvement of that extent would in the great majority of cases have shown more on the right side and would have given some symptoms. A malignant involvement of that extent would probably have caused some loss of weight and other clinical evidences of malignancy. The diagnosis, of course, cannot be made definitely, but certainly pulmonary syphilis is strongly suggested. The plate shows two processes. On the left there is probably bronchostenosis with collapse of the lung. On the right there is a diffuse rather fine peribronchial fibrosis.

The writer wishes to express his appreciation of and gratitude for the kind counsel of his chief, Dr. George W. Holmes.

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FRACTURES OF THE PELVIS*

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I WAS prompted to look up fractures of the pelvis because we have four cases in the hospital now.

Fractures of the pelvis are acquired by direct violence or force, such as railroad and automobile accidents and falling from heights. They are usually classified as minor and major fractures.

Symptoms depend on the kind of fracture, whether it is minor or major, and what portion of the pelvis it involves. Owing to the peculiar shape of the pelvis and the many different muscles attached to it, it is hard to mention all the symptoms. But symptoms are not reliable, as one of the patients was able to walk into the laboratory, and it was only because the insurance company asked for a roentgen examination of the pelvis that the fracture was found. Minor fractures are usually without complications while major fractures are frequently complicated.

Fig. 1. Case 1. Male, age forty, fell down elevator shaft, four stories. Fracture of pubes. He had no complications of any sort.

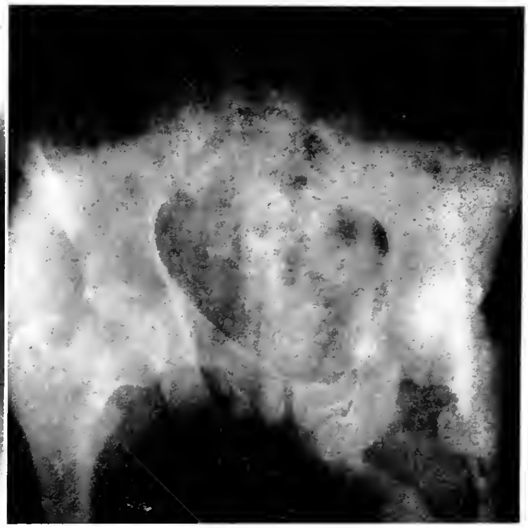

Fig. 2. Case 2. Male, age twenty-seven. Fracture of pubes, both sides. He came walking into the hospital. Had no complications of any sort.

Minor fractures are those that involve:

(1) Upper expanded portion of the ilium.
(2) Rim of acetabulum.
(3) Ischial tuberosity.
(4) Coccyx and tip of sacrum.

Major fractures are:

(1) Separation of the symphysis pubis.
(2) Fracture of the pubic and ischiopubic rami.
(3) Fracture in the region of the acetabulum.
(4) Separation of the sacroiliac joint.
(5) Transverse fracture of the sacrum, or that portion of the pelvis that enters into the pelvic girdle.

The complications of fractures of the pelvis are only a few, but they are very serious, depending upon the location of the fracture. The most common complications are:

(1) Ruptures of the membranous urethra.
(2) Laceration—bladder.
(3) Injury to large blood vessels.
(4) Injury to sacrococcygeal nerves.

Rupture of membranous urethra is due to a tear in the triangular ligament. Rupture of

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the bladder and injury to the blood vessels, especially the external iliac arteries, are usually due to some sharp spicules of bone.

Fig. 3. Case 3. Female, age thirty-eight. She was thrown from a motor and struck on her hip, fracturing both pubes; had no complications.

Out of the series of seven cases there were three with ruptured urethra and one with laceration of bladder, and all of them developed urinary abscesses. One died from hemorrhage and shock from a lacerated external iliac artery with a dissecting extravasation of blood under the entire peritoneum.

A point that I want to bring out in these few illustrations is that one cannot tell from the roentgenograms whether the membranous urethra or bladder has been injured, and if at all suspicious one should advise the passing of the catheter.

Case 1. Male, age forty, fell down an elevator shaft a distance of four stories. Sustained a fracture of the symphysis, a fracture through the right sacroiliac joint and a fracture of the lower third of both bones in both legs. He had no complications with his pelvic fractures.

Case 2. Male, age twenty-seven, fell from a bridge two weeks before this examination was made and walked into the hospital. He has a fracture of the ascending and descending rami of pubes. No complictions.

Fig. 4. Case 4. Fireman thrown from fire truck. Fracture through pubes and symphysis, ruptured urethra and multiple abscesses.

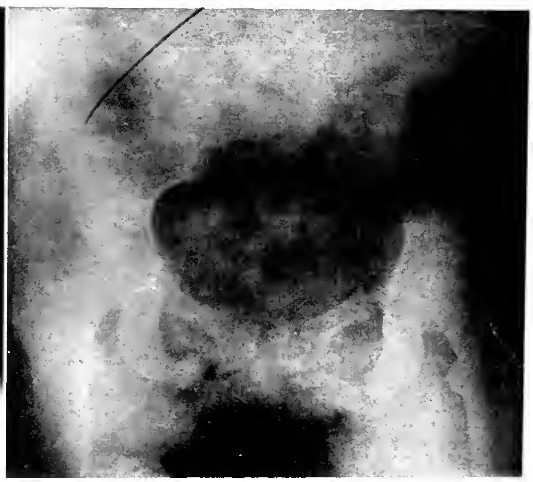

Fig. 5. Case 5. Female, age twenty-eight, hurt in interurban wreck. Fracture of both sides of pubes. This happened to be complicated by a urinary abscess.

Case 3. Female, age thirty-eight. She was thrown from a sleigh and struck her hips. Fractured both ascending and descending rami on both sides of the pubes. There were no complications.

CASE 4. Male, age forty-eight, fireman. He was thrown from a fire truck while turning a corner and sustained a fracture through the symphysis and the left sacroiliac joint. Complicating this was a rupture of the membranous urethra with many pockets of extravasated urine scattered throughout the perineum and down both thighs.

FIG. 6. CASE 6. Woman struck by an automobile. Fractured both sides of the symphysis. Died three hours later.

CASE 5. Female, age twenty-eight. This patient was in an interurban wreck and fractured both the ascending and descending rami of the pubes. She has a rupture of the urethra and many urinary abscesses; one abscess was opened in the popliteal space.

CASE 6. Female, age fifty. This patient was struck by an automobile and had a fracture of both sides of the symphysis. She was very profoundly shocked when brought into the hospital and died three hours later.

Postmortem revealed that the left deep epigastric artery was torn with a large hemorrhage which had dissected underneath the peritoneum almost all the way around the abdomen and up to the diaphragm.

CASE 7. Female, age seven. This little girl was struck by an automobile and sustained a fracture of the symphysis and the wing of the ilium through the acetabulum. She passed a small amount of blood in the urine the first twenty-four hours but this cleared up and there were no other complications.

FIG. 7. CASE 7. Little girl struck by automobile. Fracture of symphysis, wing of ilium through acetabulum.

DISCUSSION.—Most of the cases that were complicated came into the hospital several days after their injury. The urinary abscesses were drained and a catheter passed from below, if possible; if not, we would operate through the perineum and pick up the torn ends of the urethra and unite them around a retention catheter and wait until a new urethra had formed.

TWO CASES OF LYMPHATIC DISEASE IN THE SAME FAMILY, WITH ROENTGEN FINDINGS*

By CHARLES M. RICHARDS, M.D.

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THE justification for reporting these two cases at this time lies not so much in the intrinsic interest of each case separately, though indeed this was not small, but in the occurrence of two supposedly allied conditions in the same family. The rarity of this occurrence may well place it in the category of coincidence. On the other hand, it may be of some interest and value to the clinician who is trying to work out a logical interrelationship between the various lymphatic new growths, particularly in respect to their etiology. Very little of the available literature makes mention of the occurrence of these allied conditions in families, and then only to mention its rarity.

From the roentgenological standpoint, they are of interest, particularly the latter case, as illustrating the value of the new diagnostic procedure of peritoneal inflation.

CASE I. The first case came under my notice in April, 1915, being referred by Dr. J. I. Beattie for roentgen examination of the chest of a young woman about sixteen years of age, whose previous history had been negative except for the fact that one year previous to this time she had had an enlargement of the anterior cervical glands, which was diagnosed as tubercular adenitis. She was given a course of tuberculin treatment, and while the glands subsided somewhat, they did not entirely disappear, and were still present when the patient was seen at this time. About three months previous to this examination she had begun to suffer with marked dispnea, which had been constantly increasing, attended by a persistent cough. She had also begun to complain of a severe pain of an anginal character in the chest which radiated into the back and into the arms, particularly the left. There were occasional chills, with a moderate rise in temperature and rapid pulse. The patient was first seen for this complaint about April 8, 1915, and was seen by Dr. N. H. Bullock in consultation a few days later. At this examination she was found to be running a slight temperature, around 101°, with distinct evidence of consolidation in the mediastinum and left upper thorax, and signs of fluid in the left chest. The left chest was aspirated

FIG. I. CASE I. Mediastinal lymphosarcoma.

and sixteen ounces of bloody serum withdrawn. This was examined for tubercle bacilli, which were not found. The patient grew gradually worse; pain, dyspnea and cough becoming very severe, and she lost ground rapidly. She was removed to the Columbia Hospital, and a roentgen examination was made which revealed a large mediastinal tumor extending well up into the left upper chest and also less extensively beyond the right root region.

Here a confusing element entered, for a blood count had revealed a leukocytosis of about 24,000, with a large percentage of polynuclears. On the strength of this blood count a diagnosis was made of a probable mediastinal abscess. Dr. Emmet Rixford, of

*Read at the summer meeting of the Pacific Coast Roentgen Ray Society, Catalina Island, California, June 17-19, 1920.

San Francisco, saw the case in consultation, and on April 26 he and Dr. Beattie operated, and came upon a large solid tumor mass within the left chest which was diagnosed clinically as lymphosarcoma, and the pathological examination of a small gland removed at the time confirmed the diagnosis. The patient failed rapidly and died on May 1st.

Case II. A Bohemian, age seventy-five, a merchant, was admitted to the Santa Clara County Hospital about January 20, 1920. The family history was negative except that a daughter had died of a "tumor in the chest" about five years before. The past history was negative. The present illness began about nine months ago, when he said he strained himself lifting a heavy object, and injured the left ribs. There followed pain in the lower left ribs and lumbar region. This improved and grew worse at times. Four weeks previously he spat up some blood and now has occasional epistaxis. Since the strain, as he called it, he has not been entirely free from pain in his left sidė, and has considerable dyspnea on slight exertion. Physical examination revealed an anemic old man, somewhat emaciated. Pupils equal and reacted to light and accommodation. The cervical glands were all enlarged.

The blood-vessels of the neck and upper thorax were distended. There was an extreme tenderness from the ninth to the eleventh ribs in the left axillary region; the same less marked on the right side. There was bulging of the costal angle on the left, and the entire left chest appeared more prominent than the right, and lagged on respiration. The breath sounds were harsh all over the chest with a few friction sounds at the left base. Heart examination was negative. There was slight arteriosclerosis.

The examination of the abdomen revealed the liver palpable at the costal margin and in the epigastrium. The border of the spleen was felt as a firm sharp edge reaching almost down to the umbilicus. The lower abdomen was distended apparently by a full bladder, and the superficial veins were also enlarged. The back was held rigid when he moved and there was some scoliosis. The knee jerks were slightly increased.

Several examinations of the urine revealed occasional presence of considerable amount of blood. Blood examination of January 25th showed: hemoglobin 65 per cent, red cells 3,984,000, white cells 142,600, of which 97 per cent were lymphocytes. On February 17th the hemoglobin was 50 per cent, the red

Fig. 2. Case II. Lymphatic leukemia.

cells 3,256,000, white cells 112,000, of which 95 per cent were lymphocytes. On April 17th the blood showed: hemoglobin 60 per cent, red cells 2,816,000, white cells 41,400, of which 96 per cent were lymphocytes. The Wassermann reaction was negative.

On January 24th I made a roentgen examination of the chest and inflated the peritoneum with oxygen after the method of Stewart and Stein. The chest showed a dense infiltration of the glands of both roots, with lymphatic extension in all directions from the roots into both chests. The abdomen showed an immensely enlarged spleen, the notch being plainly visible in the roentgenogram, and in the liver shadow several denser areas which were taken to be patches of lymphatic tissue within the liver.

An interesting feature in this case was the

decided improvement in symptoms and in the blood picture, following the oxygen injection. So much better did the patient feel that he insisted upon a repetition of the procedure about a week later. This phenomenon has been observed by other authors in certain blood diseases. The chief observation to be made on these two cases is in reference to the interrelationship of the two diseases with the addition of the third member of the group, lymphadenoma or Hodgkin's disease. The occurrence of these two lymphatic overgrowths in a single family would perhaps suggest a little closer relationship even than has been supposed to exist, and if the presentation of these two cases has added a morsel of evidence for those clinicians who are interested in this work the justification for their publication is ample.

I am indebted to Drs. Beattie and Bullock and to Dr. D. R. Wilson for the clinical notes on these cases.

GASTROCOLIC FISTULA*

With a Report of a Case

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Gastrocolic fistula is not a rare condition, but that it is infrequently diagnosed is evidenced by the lack of cases reported in the literature. Burnham, in an excellent article on this subject, reports two cases, and in a review of the literature states that Zweig found but 70 cases reported, only 11 of which had been diagnosed during life. Voorhoeve found 105 reported up to 1912. Single cases have been reported by various others. It is thus noted that the clinical diagnosis of this condition is not common.

In the case I am reporting the diagnosis was made by the roentgen ray following the injection of a barium-mucilage-of-acacia enema and demonstrated both by the fluoroscope and the plate. The patient, male, age forty-eight, was referred by Dr. Harry Goldman.

Family History.— Married twenty-one years, three children, wife in good health, otherwise negative.

Past History.—Typhoid at sixteen years; sick six weeks.

Present History.—For the past eighteen years patient has been having trouble with his stomach; indigestion, heartburn, pain two hours p.c., constipation and headache. Pain at first was in epigastrium, and then throughout the entire abdomen. This continued for a long time without improvement until nine years ago, when he had his appendix removed and gall-bladder drained. No stones were found. In 1912 a second operation was performed. A gastro-enterostomy was done and gall-bladder removed. No ulcer of the stomach or duodenum was found. For one year the patient felt relieved as to his pain, but soon afterward the same trouble began again, except that the pain became localized in the gall-bladder area, radiating towards the back and right shoulder. The patient formerly had an attack once every few months, but lately has had attacks about every two weeks, such attacks lasting three or four days and accompanied by sharp pains, belching, nausea (but no vomiting) and headache. He noticed that for two or three days following the stools were completely white and the urine quite dark. Stools were not fatty and only occasionally were they bulky. During the last two years the patient has been accustomed to wash his stomach after an attack with considerable relief. He sleeps well, but lately

*Thesis presented with application for membership in The American Roentgen Ray Society.

is awakened by pain and obtains relief by a hot water bag and a *change of position*. He has lost twelve pounds in the last two years.

A test meal consisting of two slices of bread and a glass of water one and a half hours p.c. showed the following:

Examination by Dr. Kunstler

Amount received	80 c.c.
Color	brown
Odor	fecal
Mucus	2 plus
Occult blood	0
Free HCl	70
Total acidity	100
Starch cells	Few
Pus	0
Blood	0
Boas-Oppler	0
Necrotic tissue	0
Remarks	Feces in contents

FIG. 1. October 30, 1919. After colon enema. Stomach beginning to fill.

FIG. 2. October 30, 1919. After colon enema. Stomach partly filled.

Examination of Feces (Dr. Turck)

Color	Grayish white
Consistency	thin
Reaction	faintly acid
Bile	very faint trace
Occult blood	very faint trace
Mucus	0
Undigested vegetable fibers	few
Undigested muscle fibers	few
Pus cells	0
Blood cells	0
Fat	marked amount
Parasites	0
Ova	0
Remarks	Many fatty acid crystals

Urinalysis was practically negative. No bile was noted. Indican was normal. Albumin and sugar were negative.

The gastro-enterological report (Dr. Kunstler) is as follows: "Gastro-enterological examination reveals a very marked hyperacidity with a gastric retention and a regurgitation of feces. The case appears to be one of obstruction of the colon or an opening from the stomach into the colon, possibly from an old operative interference."

Roentgen examination was conducted on October 30, 1919. The patient was given a barium-buttermilk meal of sixteen ounces in the erect position and fluoroscoped. The stomach filled normally. Peristalsis was very active. The antrum and first portion of the duodenum lay four inches to the right of the median line and adherent to the under surface of the liver. No defect in the lesser curvature was noted. The duodenal cap filled normally without defect and was fixed by adhesions.

On the posterior wall near the middle line of the antrum and about one inch from the border of the greater curvature there was

Fig. 3. October 30, 1919. Lateral view showing gastro-enterostomy.

noted a large, patent gastro-enterostomy opening through which the meal was passing rapidly. Just below the gut widened into a large pouch-like dilatation holding approximately four ounces. Anteriorly to the gastro-enterostomy opening (as noted in the lateral position) and extending along the greater curvature for several inches the gastric wall assumed a moth-eaten appearance.

Six-hour examination showed a slight residue of about an ounce in the stomach and the remaining portion of the meal in the terminal ileum and ascending colon. Twenty-four-hour examination showed the stomach and small intestines empty. A slight amount of the meal had been evacuated and the remainder filled the colon. The hepatic flexure lay in a normal position but was fixed by adhesions. The transverse colon passed, transversely, across the abdomen from just above the crest of the right ilium to the splenic flexure which was in a normal position. No fistulous tract was noted.

A barium colon enema was then given (after a preliminary cleansing enema) and observed fluoroscopically during the administration. The rectum, sigmoid, descending and transverse colon filled normally, but the ascending colon and cecum ballooned out to

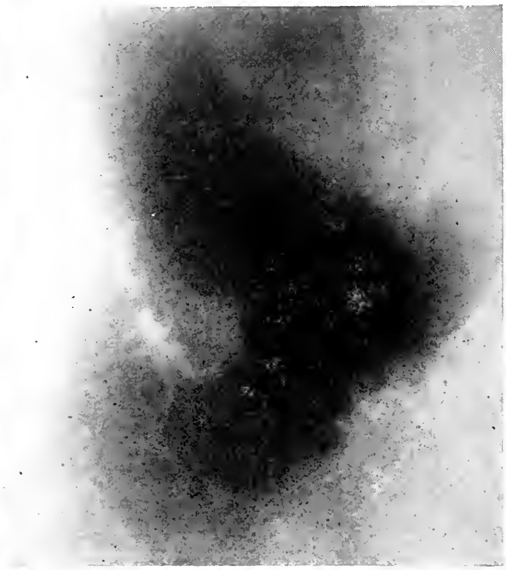

Fig. 4. October 30, 1919. Anterior-posterior view, showing gastro-enterostomy.

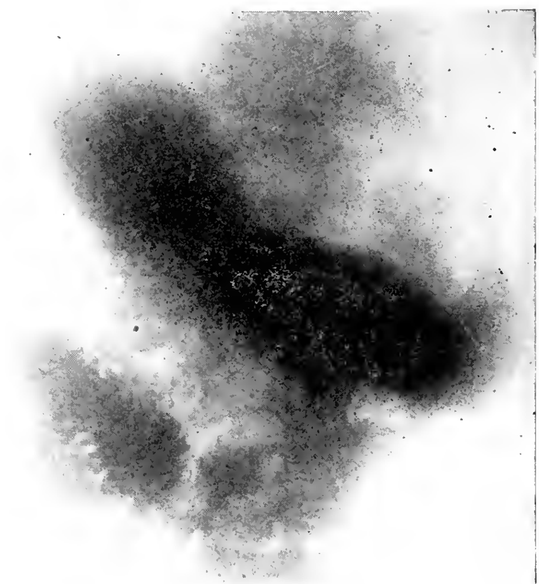

Fig. 5. October 30, 1919. Anterior-posterior view, showing gastro-enterostomy.

practically twice the size. At the same time a quantity of the barium mixture was observed spreading out through the gastric area and assuming the gastric shape and

appearance of rugae. A plate was made immediately which confirmed this observation. The opening from the colon to the stomach

FIG. 6. October 31, 1919. Twenty-four hour plate.

Three days later, after a thorough catharsis and preliminary cleansing enema, the barium enema was repeated with the same result, with the exception that the gastric area filled more fully in the region of the splenic flexure. A diagnosis of gastrocolic fistula was made.

SUBSEQUENT REPORT

Several weeks after this examination the patient went to the Mayo Clinic for confirmation and observation. During this time he had no recurrence of his gastric symptoms. He felt exceptionally well and gained a pound and a half. He was rayed there twice at intervals of about a week, and no abnormal condition was found (Report of Dr. Eustermann).

The patient returned to New York City and felt very well until about the last week in February, 1920, when he had a sudden fainting spell one evening, followed by a return of all previously noted symptoms.

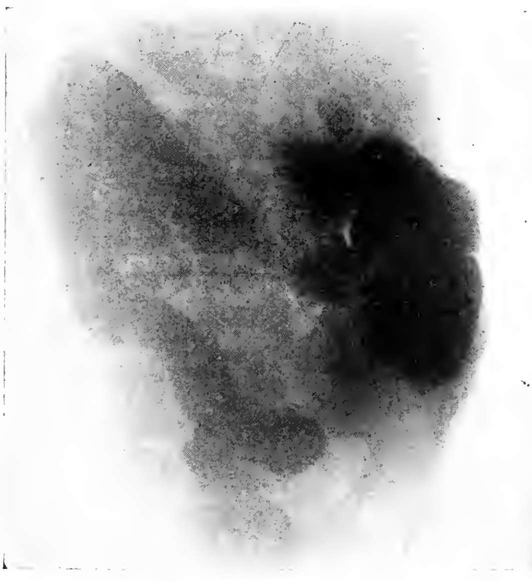

FIG. 7. March 4, 1920. Ten minutes after barium enema. Small amount of mixture in stomach.

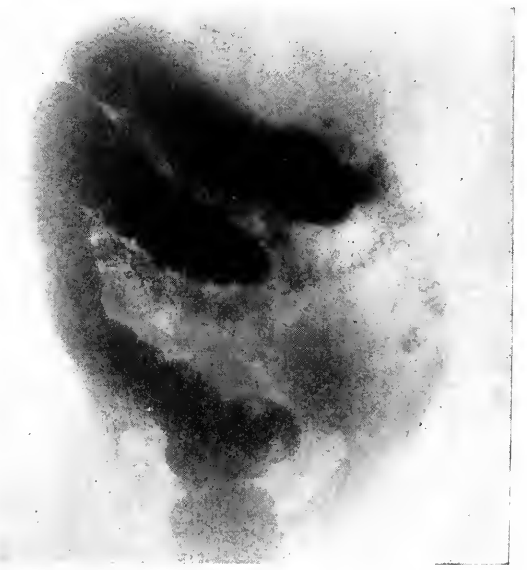

FIG. 8. March 4, 1920. Fifteen minutes after barium enema. Stomach filled. Second half of transverse colon and ascending colon empty.

could not be made out. The barium now in the stomach was a few minutes later noted passing out again through the gastro-enterostomy opening.

He was returned to me for radiographic examination. The report at this time (March 4, 1920) is as follows:

"The patient's colon (barium enema) shows, under the fluoroscopic examination during the administration, the mixture passing freely throughout without obstruction and filling out the hepatic flexure, ascending colon and cecum. Observation over a period of five minutes did not show any of the barium mixture passing into the stomach. Five minutes later a plate was made to illustrate this condition, and developed immediately, when it was noted that there was a constriction about the middle of the colon opposite the site of the gastro-enterostomy opening and that there was a small amount of bismuth in the stomach. The ileocecal valve was competent and there was no regurgitation of the barium mixture backward through this opening, excluding the possibility of the enema passing backward through the small intestines. There was noted a small amount of the mixture passing from the stomach through the gastro-enterostomy opening. Five minutes later a second plate was made which showed the ascending colon and the first half of the transverse colon, up to previously noted constriction, empty, and the stomach filled with barium mixture."

THE ROENTGEN RAY TREATMENT OF THE ECZEMA GROUP

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THIS study is an effort to obtain statistically the approximate efficiency of the roentgen ray in the treatment of the class of dermatoses which in the past we have called eczema.

One hundred cases falling under this general category were selected from the files in the office of Dr. H. H. Hazen and myself, the only consideration being that the chief reliance in treatment had been the *x*-ray and that the cases, all private, were followed sufficiently long to draw conclusions. Nine of these cases were clear-cut neurodermatitis, recently reviewed by Wise.[1] In all of these nine a clear history of mental stress had preceded the outbreak. In several there had been a number of attacks following mental stress. All presented typical lichenifications at the flexors of the elbows and knees, back of the neck, etc. This is an undoubted clinical entity, but in the past it has been called eczema, and is still so regarded by many men.[2] The other 91 cases ranged from small patches of dermatitis on the hands due to external irritation to extensive cases of generalized eczema, probably chiefly due to internal factors—soap dermatitis, primrose dermatitis, irritation from various trades, urticarial eczema, etc.

Treatment consisted in the administration of approximately one-half H skin units every two weeks over all affected areas. Our technique was 4 milliamperes, 7½ inch spark gap, 9 inch focal skin distance, 35 seconds for each application. In exceptional cases slightly smaller doses were administered every ten days. The number of treatments required to clear up the condition varied greatly, and had little relation to the duration of the disease in many cases. A patch that had been present only a few weeks might require many months to cure, recurrence occurring time after time when the disease seemed conquered; while others that had been present for years cleared up with two or three applications of the ray.

[1] WISE. *Jour. Cut. Dis.*, 1919, xxxvii, 590.

[2] See discussion of Wise's paper.

The cause, whether internal or external, played little part in the result of treatment. In general, the results were better with x-ray treatments than by any previously known method of attack, and while no effort is made to check the results in this study by comparison with cases not x-rayed, this fact was easily demonstrated many times. Frequently, to convince the patient or ourselves as to the effectiveness of the ray in a given case, we have treated only a part of the affected skin with the x-ray. Ten days later our patient has returned with the part so treated from 50 to 100 per cent better than the parts treated by other methods of internal or external dosage with drugs. In this series of 100 cases the average number of treatments per case was about three.

TABLE

Number of Cases	*Average number of treatments*	*Average duration of disease*	*Average time to cure*	*Failures*
100	2.93	135.50 weeks	7.64 weeks	4

The duration and time to cure is stated in weeks to facilitate comparison.

The duration of the attack varied from two weeks to twenty years. In many of the cases where a long duration is noted there were periods of complete or partial freedom from the disease. For the most part, however, the patients were never entirely free. One case, for instance, a trade dermatitis, had been present for ten years or more without a single interval of freedom and without ever having been affected by treatment to any extent. After six x-ray applications he has been entirely free for over a year, although he has pursued his occupation of hospital orderly, and has not changed his mode of life in any way. This is unusual, however. We have generally depended on the x-ray to cure the patient. Recurrence has been prevented by finding the cause, and stopping it if possible.

A case is considered cured when objective symptoms have entirely disappeared for several months, and have failed to reappear within the usual time of recurrence for that particular case when more than one attack had been present. In estimating the time to effect this cure and the number of treatments given, the entire period, including relapses, in which the patient was under our care was included. This acts as a balance to the duration where this term included a number of attacks with periods of freedom. The average time to cure, within the meaning of that word as here defined, was approximately two months.

Out of 100 cases there were 4 per cent failures. We considered cases as failures which did not respond at all or were only partially benefited. There were only four cases, therefore, which did not entirely clear up under treatment. In two of these we failed entirely, the other two received only temporary benefit. This percentage of cures is probably higher than actually obtained, as a few cases were not included in the study which disappeared after the first visit, because, perhaps, they became discouraged at not getting immediate results. We cannot say whether or not they could have been cured.

CONCLUSIONS

1. One hundred cases of eczema with an average duration of over two years took an average of two months and three treatments to cure.

2. Four per cent of the cases were failures.

3. The superiority of the x-ray over other forms of treatment is believed to be demonstrated for this group, and its routine use justified.

SOME REMARKS ON THE PRESENT STATUS OF X-RAY THERAPEUTICS*

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ROENTGENOLOGY and radiotherapeutics are comparatively recent terms in medicine. There are members of this Society present who have been active workers in and contributors to this science since its very beginning. It is, therefore, unnecessary for me—even if it were possible in the time at my disposal—to attempt anything like a review of the literature, or to call to your attention the names of those men whose work has placed this method of treatment on its present sound basis.

I shall, therefore, confine my remarks to a brief outline of the steps in advance which seem to me most important, and to a discussion of the principles underlying the successful treatment of disease by the roentgen ray, particularly of the results obtained in this country.

In a review of this subject, one is of necessity impressed with the failure to increase to any great extent the number of cures obtained over those of ten or twelve years ago, although during this period great improvement has been made in the apparatus placed at our disposal, and although in the fields of physics and biology discoveries of far-reaching importance have been made.

During this period the attitude of the general medical profession towards our specialty has shown a great change for the better. Ten years ago skepticism was the rule; now we are receiving the benefits of the careful work done and the conservative attitude taken by the early teachers, and opportunity for work in this field is almost unlimited.

In 1907, the American Roentgen Ray Society published in book form the proceedings of their annual meeting held in Cincinnati. Papers were read at this meeting by Pfahler, Pancoast, Johnston, Williams and others, giving the results obtained and the technique used in the treatment of carcinoma, sarcoma—the so-called blood disease, and the disease of the ductless gland. The results which were recorded in their papers compare quite favorably with those being obtained to-day, nor has there been any great change in the method of application, other than that which would naturally come with improvement of apparatus.

Why has the radiotherapeutist failed to keep step with his co-workers, the physicist and the biologist? Surely it is not because of lack of material, but rather, I think, because those men who from their knowledge and experience could have advanced the science have been overwhelmed with routine work, and have not been able to surround themselves with student workers who could carry out their ideas, as have the advanced workers in other fields.

That the Society as a whole is alive to this condition is shown by its action at the meeting in Minneapolis this year, when it was voted to establish the Caldwell lecture and the Leonard prize fund for original research. It is because of the absence of the purely research workers in our large clinical laboratories, I believe, that we have not advanced as rapidly as our colleagues. If the next ten years are not to be a repetition of the past, some individual effort must be made to remedy this evil.

Almost from the beginning, original research in this field has been directed along four distinct lines:

1. Method to determine the amount of radiation used.

2. Method for determining the quality of radiation, and the selection of different qualities for different diseases and conditions.

3. The effect of radiation upon normal and pathological tissue.

*Read before the New York Roentgen Ray Society on the Twenty-fifth Anniversary of the Discovery of *X*-Rays, New York Dec. 11, 1920.

4. The effect of treatment upon the individual as a whole and his reaction to it.

Let us consider briefly what has been accomplished under these four headings.

Method to Determine the Amount of Radiation Used.—The measure of dosage has been determined with considerable success in two ways:

(1) The direct, by measurement of the amount of radiation reaching the tissues being treated.

(2) The indirect, by measurement of the amount of electrical energy supplied to the tube, and from this computing the amount of energy in the form of radiation coming from it.

The pastille, first introduced by Sobround, and later elaborated by Holzknecht and Hampson, is an example of the first method, and for a considerable time it was the most accurate method available. There are difficulties in their use, however:

(1) They depend upon a color change, and this change is very slight. Errors of as much as 50 per cent may result from this source alone.

(2) Their rate of change varies with different qualities of radiation, long waves affecting them to a relatively greater extent than short ones.

(3) They deteriorate and become inaccurate unless kept in an atmosphere containing the proper amount of moisture. Even in the hands of the most careful and well trained men, it is probable that errors of 20 to 50 per cent occur.

Kienboeck substituted strips of photographic paper for the pastille. This eliminated the errors due to changes in the quality of rays used, but is a cumbersome and difficult method, and was never very popular in this country.

The indirect method of measurement is largely an American achievement and was made possible by the development of the interrupterless type of transformer by Snook and the hot cathode tube by Coolidge, even before the introduction of the Coolidge tube.

Sewell Cabot developed an interrupterless transformer with which it was possible to estimate with considerable accuracy the radiation from a gas tube; and in 1914, I published in the JOURNAL of this Society a table of dosage based on the amount of electrical energy supplied to the tube when using a Cabot machine.

The Coolidge tube has greatly simplified this method of measurement, and the work of MacKee, Shearer and others has caused the indirect method to be generally adopted throughout America. It has the advantage of convenience, and is probably more accurate than pastille or paper, but is by no means entirely satisfactory. The table of dosage used with one machine cannot always be used with another, particularly if the wave form is different. The voltage is still a difficult factor to determine, and the amount of radiant energy coming from a tube does not depend entirely upon the amount of electrical energy supplied to it.

A method of direct measurement which has not yet come into general use, but which seems to offer considerable promise, is the ionization chamber adapted for practical work. With this instrument it is possible to measure with considerable accuracy not only the amount of radiation reaching the part being treated, but by placing a second chamber below, the amount actually absorbed can be measured.

Method for Determining the Quality of Radiation, and the Selection of Different Qualities for Different Diseases and Conditions.—Although it has been shown experimentally, at least, that the effect of radiation does not depend upon kind, but upon quantity of rays absorbed, it is still necessary to use rays of a certain quality to obtain the maximum effect at different levels below the surface.

Many of the early writers recommend the use of the "hard tube" in the treatment of deep-seated lesions, and in 1905, Pfahler adopted the use of filters to shut out the soft rays.

The more recent work of the Braggs has made it possible to analyze x-radiation, and to formulate laws governing their production and absorption. But as yet no practical

method has been devised for using rays of a single wave length in the treatment of disease. Until this can be done, some of us who have seen metastatic nodules in the skin which persisted through a full course of treatment with filtered radiation disappear rapidly when unfiltered rays were used, will doubt the statement that quantity and not quality is of supreme importance.

There is a tendency at the present time to use rays of shorter and shorter wave length, and it is quite possible that we are reaching a point where the rays used may pass to a large extent through the diseased tissue and produce unnecessary injurious effects upon the underlying organs. The very short wave lengths have been used in an effort to save the overlying tissues; perhaps more reliance should be placed upon cross firing and upon increasing the target skin distance. The value of distance in equalizing the dose throughout a given mass of tissue is well known and is explained by the inverse square law.

During the past year I have used a 16 inch target skin distance where I was especially anxious to avoid an erythema or where the mass treated was unduly large or deep, and I am sure that my results have been better than with the standard 8 inch distance. The Huntington Hospital of Boston is planning to use a 24 inch distance. I am aware that there is nothing new in this suggestion, but I believe that it is not sufficiently well recognized in this country.

The Effect of Radiation upon Normal and Pathological Tissue.—Dr. Robert B. Greenough, in July of this year, read a paper before the International Society of Surgeons, in which he discusses at considerable length the biological and therapeutic effects to be expected from treatment with *x*-rays or radium. He sums up the present knowledge of this subject as follows:

1. Living tissue may be destroyed *en masse.*

2. Growth may be temporarily inhibited.

3. Rapidity of growth may be stimulated.

4. The manner of growth may be modified.

And he further states that in the terms of these four phenomena, we must consider the action of radiation in the treatment of disease.

There seems to be ample support for Greenough's conclusions. His statements are based on the results of laboratory experiments conducted by physicists and biologists, both in this country and abroad. They are also borne out to a considerable extent by clinical observations. He believes that in the treatment of malignant disease, in order to produce a cure, all of the malignant tissue must be destroyed, and that mass destruction is the only way to bring about this result.

If we grant this hypothesis, there can be very little if any possible advantage in treatment by radiation over that of surgery, a possible exception being those superficial lesions occurring in positions where scar formation is to be avoided.

There is, however, I believe, an equally good theory, namely, that malignant disease may be destroyed by stimulation of the connective tissue around it, in this way shutting off its blood supply and arresting development. Nearly every pathologist who has studied the effect of radiation has noted that connective tissue changes are the earliest to appear, and that they are a characteristic finding in tissue which has been under prolonged radiation.

Dr. Wolbach of the Harvard Medical School is an advocate of this theory. Dr. Martin, working with Dr. Wolbach, made some experiments on rabbits which to some extent confirmed this theory.

Another possibility of the cause of cell destruction by radiation is that some antibody or ferment is produced in the blood or tissues which has a destructive or inhibiting action on tumor cells. Dr. Crane suggested such a possibility in 1907, and there is a large amount of experimental and clinical data which seems to confirm such a theory.

That radiation is capable of inhibiting growth can be demonstrated by observing its effect upon individual cells.

If a mononuclear organism, such as paramecium, be exposed to a sufficient amount of

x-radiation, cell division ceases; but if the dose is not sufficient to kill the organism, and the animal is not exposed to repeated doses, it will soon begin to divide and the rate of division will be considerably increased, so that in a short period of time the rayed animal will have divided as many times as an unexposed organism used as a control.

This power of inhibiting cell division and of maintaining it for considerable periods of time, is of practical importance to us in treatment, particularly in treating a glandular disease, such as hyperthyroidism. It may not be necessary to destroy with massive doses the structure of the thyroid gland, but by giving a relatively small dose at rather frequent intervals, we may inhibit its function and maintain it until the vicious circle has been broken and the individual recovers from the disease. In the treatment of deep-seated malignant disease, where it is not possible to destroy all of the pathological tissue, radiation should be sufficiently frequent to maintain this inhibiting power.

Modification of Cell Growth by Radiation.—In addition to its destructive, inhibiting and stimulating powers, the action of radiation on organisms tends to modify and influence its growth. Irregularities take place, and changes in the shape and characteristics of the cells have been noted. When frog's eggs are rayed, monstrosities will appear among the tadpoles. This has also been demonstrated when using the eggs of fowls. When pregnant guinea pigs and rabbits are subjected to heavy raying, similar monstrosities have been produced. Recently a case was reported in which an abnormality of this kind appeared in the human fetus, where the mother had been treated for fibroids. Attemps to stimulate normal cells by radiation until they take on malignant form has, however, so far been unsuccessful. In applying radiation should be sufficiently frequent to therefore justified in hoping that the modification will be a beneficial one.

The Effect of Treatment upon the Individual as a Whole, and His Reaction to it.—That prolonged or extensive radiation may have a profound effect upon the individual as a whole is well known, perhaps the most striking evidence being the so-called treatment sickness, the exact cause of which is unknown. One of the early theories advanced was that this sickness was caused by inhalation of gases produced by the high potential discharge. Pfahler was able to diminish somewhat the amount of sickness occurring in his patients by better ventilation in the treatment room, but this theory does not fully account for the condition, as similar symptoms have occurred after heavy exposure to radium. Lang suggested the possibility of acidosis and recommended the use of sodium bicarbonate. More recent studies of the blood, particularly of the blood nitrogen, indicate that the acidity is somewhat raised after radiation, and that this is due to an increase in the hydrogen ion content. Much more work will be necessary before one can make any definite statements as to the cause of treatment sickness. Probably there are several factors entering into it, the most active of which is due to some obscure change in the blood.

Other evidence which we have of the general effect of radiation is the improvement in the general well-being of the patient. This is apparently brought about to a considerable extent by an increase of metabolism. That the metabolic rate is increased has been shown by studies on individual cells and by basal-metabolism tests of individuals undergoing treatment.

Other evidence which should not, perhaps, be classed as affecting the organism as a whole, but in which the effect is not entirely local, are such findings as the disappearance of glands at a distance from the part rayed, a frequent occurrence in Hodgkin's disease. Knox observes that patients with malignant disease who have a fairly good color index respond much better to radiation than those in whom the red count is low, and he attributes this to the better opportunity for the production of secondary radiation from the hemoglobin in the blood in cases with a high or normal red count.

Smith and Clapps have injected the blood of a patient suffering from leukemia who

had previously derived benefit from x-ray treatment into unrayed patients suffering from the same disease. This procedure produced a decided drop in the white count in the blood of the patients so treated, whereas the injection of normal blood or blood from untreated leukemia patients caused a raise in the count.

In a recent discussion of this subject with Dr. George Minot he stated that he had observed that the glutinating properties of the blood are diminished after radiation, that is, the blood of patients who have had typhoid fever loses to a considerable extent its power of causing clumping of the typhoid bacillus.

A theory has been advanced that the activity of radiation on tissues is due to the action of enzymes, and that the ionization of the tissues by changing the acidity of the tissue juices stimulates or depresses these enzymes. The literature on this subject was carefully reviewed, and some additional original work presented by Richards in 1914.

All this data, which has been accumulated in the laboratories, is of importance in the treatment of the patients who come to us for relief, particularly that group which constitutes the greater number—those suffering from malignant disease, and we must not rely entirely upon any one method or theory.

Once a malignant growth has metastasized, permanent cure is not to be expected by any means. Surgical statistics do not give us any great hope, particularly if we exclude those cases with enlarged glands of inflammatory origin. In my personal observations I have been disappointed with the results of postoperative and pre-operative raying. I have seen very rapid recurrence take place, even recurring in the skin of patients who were at the time being subjected to heavy roentgen therapy.

When a patient suffering from malignant disease presents himself at the clinic, he should be considered in the following manner:

1. Is there any evidence that the disease has metastasized? If not, complete removal by surgery should be undertaken at once with every hope for permanent cure. If metastasis has taken place, we must decide whether we are going to attempt a complete cure or whether our treatment shall be palliative. If we decide that there is hope of a complete cure, surgery is still probably the method of choice, but I believe that where extensive dissections are required, the results will be disappointing. If surgery is not attempted, then we may treat with x-ray or radium or both, and here again two methods are open to us.

2. Shall we attempt a complete destruction of the malignant cells regardless of the pain and discomfort which we are likely to cause the patient, even continuing the dose to a point which brings on actual sickness, or shall we confine ourselves to a dose which will not produce painful erythema, keeping the number of areas so limited that the patient's natural resistance will not be destroyed by repeated attacks of sickness, and using a ray of not too great penetration, with a distance sufficiently great to warrant an even distribution through the part being rayed?

In this way we may hope to inhibit the growth of the malignant cells, and at the same time stimulate the production of a limiting envelope of connective tissue.

When one considers the extremely small number of cures of malignant tumors by any method after metastasis has taken place, I believe the latter procedure is more rational. In this way life is prolonged and made comfortable. The superficial lesions—such as the large ulcers—are avoided, and death occurs usually from deep metastasis.

Recently we have had a small group of cases of carcinoma of the breast in which there was evidence of metastasis, glands being palpable in the axilla and above the clavicle. For this or other reasons they were not operated on, but were subjected to x-ray treatment alone. These cases have certainly done much better than similar cases operated upon and followed by radiation.

I cannot but feel that the operation in some way breaks down the natural resistance of the patient, and interferes with the wall-

ing-off process which is the result of connective tissue stimulation.

In the treatment of non-malignant disease it is quite possible that it is not necessary to attempt cell destruction, but that a dose sufficient to inhibit cell activity maintained over a considerable period of time is all that is necessary or required.

Waters in his experiments on dogs and rabbits was unable to produce any definite changes in the thyroid gland unless the dose was sufficiently large to produce permanent injuries to the skin.

My own observations in the treatment of hyperthyroidism rather confirm this idea. I have yet to see a case of myxedema proved positively to be due to *x*-ray treatment. Cases have occurred while under radiation, but myxedema is a fairly common end resultant in hyperthyroidism.

A small group of cases which suddenly dropped to below normal under treatment have since returned to normal, suggesting that their symptoms were due to inhibited glandular function rather than destructive. A case of malignant thyroid, who has had heavy radiation off and on since 1913, has a metabolism to-day which is only ten points below normal. The average radiologist doing fluoroscopic work has his thyroid region exposed to a considerable amount of radiation of a short wave length. If the amount received is very small it should produce stimulation. If it is sufficiently large it should destroy the gland. With this idea in mind, I recently had my own metabolism done, and it was a few points below normal. Apparently the amount of radiation which I have received has had no stimulating effect upon the thyroid gland. It would be interesting, I think, if other radiologists would have this simple test made.

In closing, I again wish to call your attention to the necessity of developing a group of clinical workers in our large *x*-ray laboratories, and to the importance of better cooperation with the internist and surgeon. What little success we have had in the treatment of goiter at the Massachusetts General Hospital has been due, I am sure, to a very large extent, to the good cooperation which we have had with the clinical laboratories, the internists and the surgeons.

The cases have been very carefully selected. The progress of the treatment has been followed by all available means, and no therapeutic measure which would be of benefit to the patient, such as rest and sedative drugs, has been neglected. What is true in the treatment of goiter is equally true in the other diseases which we are called upon to treat.

THE REDUCTION OF RADIOGRAPHIC EXPOSURES TO ONE TWENTY-FIFTH OF THE NORMAL AMOUNT BY MEANS OF THE "IMPEX" X-RAY PLATE

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AND

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THE question of the reduction of radiographic exposure to the lowest amount possible is one of the utmost importance to all roentgenologists. Progress in this direction has for many years past been achieved almost entirely by increasing the power of the unit supplying the high tension discharge and by the improvement of the *x*-ray tube. Some advance has been effected by improvement of intensifying screens, by the use of which excellent radiographs can now be obtained, with a ratio of reduction in exposure of one-fifth to one-tenth according to the subject.

In spite of the fact that sufficiently powerful apparatus is in existence to permit of exposures of a fraction of a second on any medical subject, the demand for still further rapidity on the part of the *x*-ray plate is as insistent as ever, not only to reduce the period of exposure, but to enable the distance between the *x*-ray tube and the plate to be increased in order to obtain better definition.

If the various measures taken to effect reduction of exposure be considered, it is somewhat remarkable that for many years past the speed of the plates employed for radiography has remained practically constant. It would almost appear, indeed, that with the present type of plate a limit has been reached.

In view of this fact, that the speeds of all plates produced by various manufacturers of the highest repute are about the same, it does not appear to be likely that experiments upon the ordinary lines of plate manufacture would lead to a considerable reduction in the exposure required. A trifling increase in speed might possibly be attained, but a considerable multiplication could not reasonably be expected.

For these reasons, it was thought best to consider the production of a plate upon entirely new lines, and the question of the production of a plate and intensifying screen in one soon presented itself as a possible solution. We had been aware for a long time that the normal reduction of exposure effected by an intensifying screen, say 10-1, was by no means the limit attainable with the plates available and with the type of calcium tungstate used for the production of intensifying screens. For example, if the salt were coated on the screen with just sufficient emulsion to retain it on the backing, an increase of speed of 15-1 could be obtained (as compared to the usual 10-1). Such a screen would be useless in practice as the surface is too fragile. This observation served, however, as an indication, and it might reasonably be expected that a still closer contact between the fluorescent substance and the sensitive film might well lead to a considerable further increase in the efficiency of the salt as a means of reducing exposures.

The fluorescent material might be mixed in with the emulsion before coating. This method would not, however, be likely to be effective unless the fluorescent material were transparent. In addition to this the resulting image would almost certainly be grainy and the method of production would to some extent defeat its own object. Owing to the separation of the particles of reduced silver on the plate by the particles of fluorescent salt, the net effect of this construction would

be to reduce exposures to a certain extent on this account.

The alternative method of production is to have the fluorescent material coated as a layer in contact with the sensitive film. A plate for radiography, constructed in this manner, must fulfil certain desiderata before it can be considered. These requirements are:

1. Technical perfection of the resulting radiograph. The image must be absolutely free from grain and from any mechanical faults, and must be equal in this respect to radiographs made from ordinary x-ray plates without intensifying screens.

2. With certain subjects both perfection of detail and degree of contrast leave something to be desired in the case of ordinary x-ray plates. In these respects it is desirable that a new plate should not merely equal but should excel existing types of plates.

3. The cost of the new plate must not be materially greater than that of existing plates.

4. The use of the new plate must not introduce any manipulatory difficulties. It should be just as simple to use and to develop as the existing type of plate.

In order that these desiderata may be completely fulfilled, it is quite obvious that the fluorescent material must be far more effective than it is in the case of the most efficient intensifying screens so far produced. If the radiographs produced by the use of an ordinary x-ray plate and an intensifying screen are considered in the light of the desiderata mentioned, it will readily be perceived that none of the requirements are properly fulfilled. For example:

1. The screen image is always slightly more grainy than a radiograph taken without a screen.

2. When an intensifying screen is used, mechanical faults are liable to occur owing to particles of dust on the screen—the surface of the latter becoming soiled, or to bad contact due to inefficient or warped cassettes, etc.

3. The fitting of a screen and plate into a cassette is a little troublesome and means multiplication of screens and cassettes for a sequence of exposures.

4. The cost of the fluorescent material per screen if coated on a plate would increase the cost of the latter several hundred per cent.

If the fluorescent material were coated on the plate so as to be in optical contact with the light-sensitive emulsion, we may reasonably expect to obtain a much better result, because there will be no absorption of the fluorescent light by any coating medium before it has a chance to affect the light-sensitive film.

After a large number of experiments a plate has been produced which we believe marks a considerable advance and in which the desirable characteristics which have been enumerated have been completely fulfilled.

This plate, which has been given the name of the "Impex" plate, was first described at a meeting of the Roentgen Society in December, 1920. The present paper, while it embodies all the introductory information contained in the first communication, contains in addition a variety of facts concerning the application and use of the new plate, which facts have become known as a result of the actual manufacture and use of the plate on a large scale.

DESCRIPTION OF THE IMPEX PLATE

The Impex plate consists essentially of an x-ray plate coated with a special type of silver-bromide emulsion, on which is coated as a second layer a small quantity of specially prepared fluorescent calcium tungstate.

The light-sensitive emulsion is composed of specially hardened gelatine, in order to facilitate the subsequent removal of the fluorescent coating (henceforth termed the "Impex layer") without any injury to the former.

The coated plate is exposed for a very short period, which may be anything from one-twentieth to one-thirtieth of the normal exposure and which varies with the nature of the object to be radiographed and the hardness of the tube (q. v.). Before develop-

ment the plate is placed in warm water for two or three minutes, when the top layer containing the calcium tungstate dissolves off. The final portions of this coating can if necessary be removed by rubbing with a pad of cotton-wool. Owing to the special nature of the light-sensitive emulsion, the latter is entirely unaffected by this treatment, and the plate is then developed and fixed in the usual manner.

If the plate is placed in the vertical plane, in a tank containing warm water, the top layer dissolves off and sinks to the bottom. A slight rinse under the cold water tap is all that is necessary before developing and fixing in the usual manner.

MODUS OPERANDI OF THE IMPEX LAYER

It will at first sight appear that the Impex plate is merely a combination of a plate and intensifying screen in one. Such, however, is *not* the case. The method of construction of the plate is such that entirely new and hitherto unknown factors are beneficially brought into play, with the result that the characteristics of Impex radiographs differ both from radiographs taken with ordinary x-ray plates and from those obtained by the use of an ordinary plate or double-coated film with intensifying screen or screens.

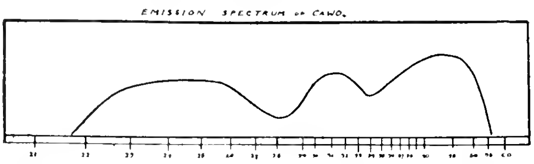

FIG. 1. Emission spectrum of calcium tungstate.

The fluorescence of calcium tungstate under x-rays may now be considered. The authors have proved by experiment that if the calcium tungstate is in optical contact with the silver bromide emulsion, it is thirty to fifty times more efficient in reducing exposure than it is if used in the form of an intensifying screen. This observation immediately brought the question of the coated plate into the realm of practical realization. The reason for this enormously enhanced efficiency is elucidated by the accompanying curve showing the emission spectrum of the fluorescence of calcium tungstate when excited by x-rays. (Fig. 1.)

It will be observed that a considerable proportion of the fluorescence of this salt occurs in the ultra-violet region. These short waves are entirely absorbed by the various media of which intensifying screens are constructed, and their actinic effect upon the plate is therefore entirely lost. In the Impex plate they are completely conserved, and the results prove that these short waves are many times more potent actinically than the longer waves which are the only ones effective in the case of intensifying screens.

The sensitive emulsion of the Impex plate is treated so as to possess two maxima of sensitiveness, one in the blue violet (visible) and another in the ultra-violet, the center of which is about $\lambda = .245\,\mu$. These correspond fairly approximately to two of the maxima in the emission spectrum of calcium tungstate when excited by x-rays. This inter-adjustment of sensitiveness of the emulsion to the emission spectrum maxima is responsible for a considerable increase in the speed of the plate.

Apart from speed, the optical contact of the Impex layer on the sensitive emulsion has the effect of totally eliminating graininess on the resulting negative. However tightly an intensifying screen is pressed against the film of the plate during exposure, it is never possible to get anything like true optical contact, and the resulting irradiation due to imperfect contact between the fluorescing material and the sensitive emulsion militates against obtaining the best definition.

MANIPULATION OF IMPEX PLATES

A. *Removal of Impex Layer.*—The Impex layer is readily soluble in water at a temperature of 105° to 110° F. (The precise temperature is immaterial.) A convenient method of removing this layer is by standing the plate in a tank containing warm water at about 110° F. A number of plates are placed

in the tank and are removed for development as required. After standing for two or three minutes, the Impex layer dissolves off and sinks to the bottom of the tank. A rinse for a few seconds under a cold-water tap, together with a slight rubbing with a tuft of cotton-wool, serves to remove the residual powder which still adheres to the plate. By the use of the tank method of removal, the increase of time required is less than one half minute per plate and the manipulation is actually quicker than using an intensifying screen. The plates are quite uninjured by being left in the warm-water tank until it is convenient to proceed with their development. If preferred, however, each plate may be treated separately in an ordinary developing dish containing warm water. A preliminary soaking of three minutes serves to render the Impex layer easily removed by a tuft of cotton-wool when swilled under a cold-water tap.

B. *Development.*—Owing to the fact that the emulsion has absorbed water during the removal of the Impex layer, it is desirable to use developer of rather more than the usual strength. This counteracts the dilution which it experiences on diffusing into the wet film. Equally good results can be obtained with developer of ordinary strength, but the development will require a little longer for its completion. Great care must be taken that the developer is completely in solution; otherwise black spots are certain to be produced.

C. *Fixation.*—The plate is fixed in an acid-fixing bath in the usual manner. Owing to the special nature of the emulsion, fixation is rapid and is complete in less than five minutes. Very little density is lost in this operation. The plates should not be exposed to actinic light until completely fixed.

D. *Safe-lights.*—The excessive sensitiveness of the Impex plate to ultra-violet light renders it necessary to employ a suitable safe-light. A special greenish yellow light is recommended, the transmission spectrum of which is shown in Figure 2 (top). Some green and orange safe-lights transmit ultra-violet light and are thus unsuitable, but a good ruby light is perfectly safe.

A comparatively slight amount of light-fogging considerably reduces the sensitiveness of the emulsion to x-rays, and hence the

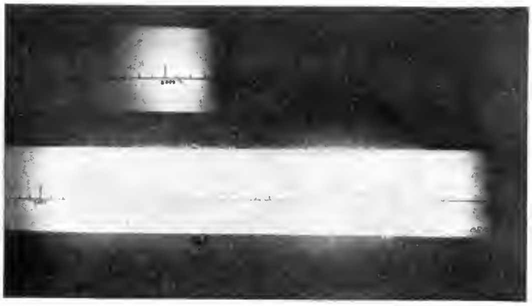

Fig. 2. Transmission spectrum of safe-light.

importance of employing a safe-light of the correct type is obvious.

CHARACTERISTICS OF IMPEX RADIOGRAPHS

A. *Reduction of Time of Exposure.*—1. As already stated, the calcium tungstate is, quantity for quantity, at least thirty times as efficient as when it is used in an intensifying screen. If an intensifying screen and a sheet of glass, coated with the same layer of calcium tungstate as is applied to the new plate are exposed to x-rays, it will be perceived that the visible illumination of the screen is many times greater than that of the plate—which is very feeble indeed. In spite of this fact, the effect photographically of the coating on the plate is four times as great as that of an intensifying screen.

2. In the radiography of the thinner parts of the body, such as the foot and knee, the exposure is reduced to one twenty-fifth of the normal exposure required with the x-ray plate already in use. Figures 3 and 4 show respectively an ankle and a knee taken on the Impex plate with one twenty-fifth of the normal exposure for these subjects. The details shown in the bones may be noted.

Figures 5 and 6 are respectively radiographs of a foot in a boot, Figure 5 taken on an ordinary plate and Figure 6 taken on an

Impex plate with one twenty-fifth of the exposure. These radiographs are reproduced by the kind permission of Dr. Thurstan Holland.

In the radiography of the thicker portions of the body, such as the pelvis, the exposure is reduced to about one twentieth of the normal amount at present required. Figures 7 and 8 are comparison radiographs of a head. Figure 7 is taken on an ordinary plate and Figure 8 on an Impex plate with one twentieth of the exposure.

Fig. 3. Radiograph of ankle taken on Impex plate.

B. *Freedom from granularity and clearness of image.*—The fact should be emphasized that in contradistinction to all exposures made with an intensifying screen, the results obtained with the Impex plates are entirely free from graininess and are equal in this respect to the best results obtained with the present *x*-ray plates without a screen, which require twenty to thirty times the exposure. It is practically impossible to over-expose the new plate. Should it accidentally be given two or three times the necessary exposure it is only necessary to reduce the final development; the resulting negative is just as brilliant as if the correct exposure had been given. No graininess at all is produced in cases of overexposure as is the case when intensifying screens are employed.

With regard to contrast in such a subject as the pelvic region and in regard to detail and brilliancy of the image, the Impex plate compares very favorably with the ordinary plates at present in use. Another advantage, which is directly due to the very short exposure required, is the superior sharpness of outline obtained owing to the relative immobility of the patient, who is capable of keeping perfectly still for the very short exposure required with the new plate, but who cannot possibly do so for a much more prolonged period.

C. *Gradation and Range.*—It is generally recognized in radiography that the shorter wave-lengths—as emitted by a hard tube—give less contrast and conversely the negative obtained with a soft tube is more brilliant, provided the penetration is adequate for the subject radiographed.

Fig. 4. Radiograph of knee taken on Impex plate.

The scale of gradation obtainable with an *x*-ray plate of the ordinary type is therefore strongly selective. The technique of the Impex plate is, however, entirely different. Hard rays excite a far more powerful fluor-

escence in the Impex layer and the tube should always be worked in a hard condition—preferably about 7 inch equivalent spark-gap or more.

This method of working does *not* destroy definition in the very soft tissues, for which very *hard* rays, and these are the conditions in which the maximum reduction of exposure, coupled with the greatest detail and contrast, are obtained. This point requires special emphasis, as in certain cases where the maximum reduction of speed was not

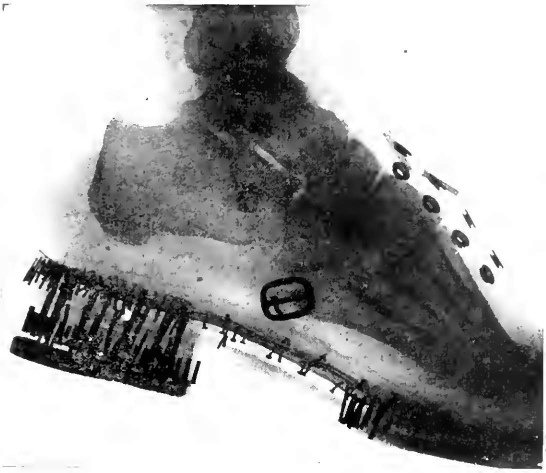

Fig. 5. Radiograph of foot in boot taken on ordinary plate.

Fig. 6. Radiograph of foot in boot taken on Impex plate with one twenty-fifth the exposure.

Fig. 7. Radiograph of head taken on ordinary plate.

Fig. 8. Radiograph of same head on Impex plate with one twentieth the exposure.

in the ordinary way a soft tube would be employed. The full scale of gradation and in fact, a far wider scale than has been obtainable before, is obtained with the Impex plate exposed under the *softest* tissues with obtained, this was found to be due to the use of too soft a tube. For example, at 4 inch equivalent spark gap, the reduction is only 4 to 1.

The great reduction of exposure will un-

doubtedly be of considerable service in the x-ray examination of metals and the like. This is a comparatively recent development of radiography and suffers at present from the drawback of requiring very extended exposures in order to penetrate masses of metal. The reduction of, say, 20-1 on a 20 minutes exposure, means far more actually than the same ratio of reduction on an ordinary exposure of, say, 20 seconds or less required for the radiography of the body. The prejudicial effects of secondary radiations when radiographing considerable thicknesses will be obviated. Figures 9, 10 and 11 are radio-metallographs taken in the fraction of a second on the Impex plate, the ratio of reduction of exposure being about 30-1. Figure 9 is an alarm clock radiographed in its case. Figure 10 is an electric switch. Figure 11 is a direct vision spectroscope. The flint crown glass prisms are clearly differentiated.

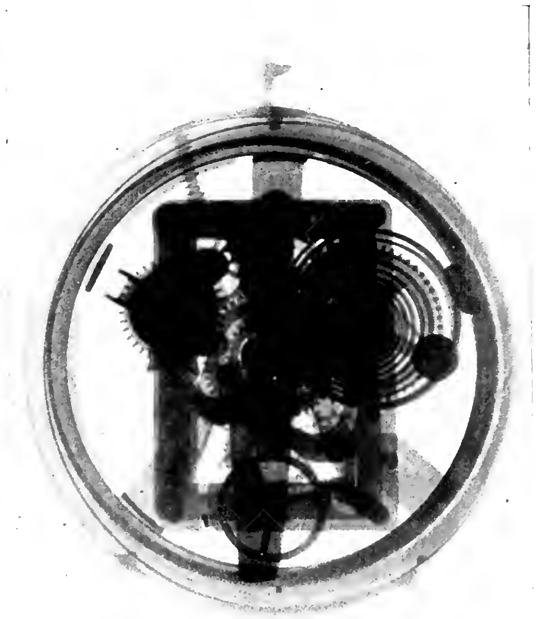

FIG. 9. Alarm clock radiographed in its case.

The great reduction of exposures afforded by the use of the Impex plate is advantageous in many other respects. The possibility of taking the number of radiographs without the risk of burns and without the production of other undesirable results is of course perfectly apparent.

A by no means negligible advantage is that of the reduction of wear and tear upon apparatus, especially upon tubes. The number of exposures per tube is greatly increased, and whereas during the course of a comparatively long exposure a gas-filled tube will often vary its vacuum and so give rise to variable results, this trouble should not be experienced with the very short exposures necessitated with the new plates.

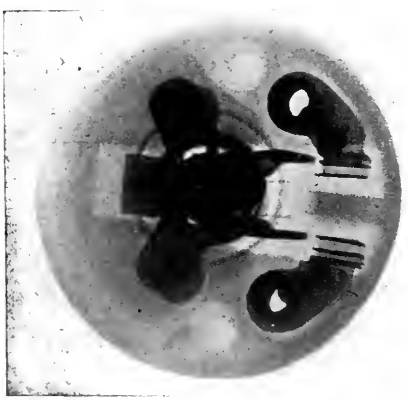

FIG. 10. Electric switch.

FIG. 11. Direct-vision spectroscope with flint crown glass prisms clearly differentiated.

The capacity of low power installations is considerably increased. Results can now be obtained with a 12 inch and even with a 10 inch low capacity coil set which were formerly possible only with far more expensive and powerful outfits.

The results so far obtained are to be regarded as purely preliminary. It is hoped that further experimentation will enable still better results to be obtained. By inter-adjustment of the absorption spectrum of the film to the color of the fluorescence of the intensifying salt used, a further improvement may confidently be expected, and the reduction of exposure to even 1/100th of their present values should not prove an impossibility.

Various new possibilities present themselves. For example, a cinematographic radiograph of the heart beating should be readily obtainable with ordinary apparatus.

Double coated films can be made on the same lines as the new plate, each light-sensitive emulsion being provided with its removable fluorescent layer. It may also be confidently anticipated that the radiographic examination of metals and other materials will be carried out on objects at present not attempted owing to the large exposure necessitated.

The experiments leading to the invention of the Impex plate were undertaken at the instance of the Cox-Cavendish Electrical Co. Ltd., of London, for whom the preliminary work was carried out in Dr. Leonard Levy's laboratory.

The great speed of the Impex plate is undoubtedly due in part to the use in its preparation of a special ultra-violet sensitive emulsion which had previously been developed for screen plates in the laboratory of the Imperial Dry Plate Co., Ltd., under the direction of Mr. Thorne Baker, who was also responsible for working out the manufacturing details concerning the coating of the Impex layer.

THE EFFECT OF RADIUM EMANATION ON THE ADULT MAMMALIAN BRAIN*

AN EXPERIMENTAL STUDY UPON ANIMALS, WITH SPECIAL REFERENCE TO THE THERAPEUTIC DOSE IN THE TREATMENT OF BRAIN TUMOR

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NEW YORK CITY

THESE experiments are primarily concerned with the histological changes following exposure of the adult brain to radiation from radium emanation, and the extent to which a normal brain may be radiated without destroying normal functional activity.

It is well known that adult nervous tissue is resistant to radiation, and from experience in the treatment of neoplasms other than those of the brain, one would expect that certain cellular types of cranial tumors would react favorably to radiation.

The unsatisfactory results of surgical removal of brain neoplasms justify this preliminary work, designed to obtain data for the treatment of such growths by physical agents. The question of dosage and technique in utilizing the large supply of radium now at the Memorial Hospital becomes pertinent. It will be appreciated that the methods of utilizing the radium emanation from four grams of radium metal may be quite different from those employed by previous workers using only a few hundred milligrams of the element.

Brain tumors have been treated for some time by means of radiation. The *x*-rays have generally been utilized alone, and in several cases combined with radium. Quick[1] in his recent paper on the utilization of radium and *x*-rays in the treatment of hypophyseal tumors has given a fairly complete bibliography of the more important papers. Fewer reports have concerned the use of radium alone in the treatment of such growths, and by far the most extensive is a recent paper by Frazier[2] reporting several years of experience. Simultaneously with Frazier's recent report, his associates, Williamson, Brown, and Butler[3], gave a preliminary account of an experimental study of the effects of radium on normal brain tissue. Fortunately, the work of the writer, begun over two years ago, tends to extend and supplement rather than repeat the later investigations. Their principal results, as well as the previous researches in this field, will be discussed later on in this paper.

METHODS AND APPARATUS

Four methods were used: 1. Unfiltered† radium emanation contained in minute glass tubes was permanently inserted beneath the scalp in small animals (rats), and directly in the brain tissues in others—rats, guinea pigs, rabbits and dogs. Small doses of radium emanation were used in this group, each tube containing from 0.2 to 1.5 millicuries. 2. Larger doses of unfiltered radium emanation, 63 to 255 millicuries, were placed in the brains of rabbits and dogs and left in place for varying periods. 3. A comparatively large amount of radium emanation, filtered by 1 mm. of platinum, and contained in a capsule applicator, was inserted in a dog's brain for thirty-five minutes. 4. Two large doses of heavily filtered radium emanation, 4000 and 9000 millicurie hours respectively, were applied externally over the head, in the case of dogs, and a still larger dose of 12,030 millicurie hours was applied in a similar manner over the left temporal region of a monkey.

†That is, the only filter was from 0.1 to 0.2 mm. of glass.

*Read by invitation before the New York Neurological Society, New York Academy of Medicine, Dec. 7, 1920.

The small glass tubes containing radium emanation vary from 2.5 to 4 mm. in length, and are about 0.4 mm. in outside diameter, with containing walls about 0.1 mm. thick. The trocars were 0.8 mm. in diameter at the small end, at which place the radium tubes were inserted. After the trocar was inserted in the tissues, it was slightly withdrawn before pressure on the stylet released the radium tube. For further details concerning this technique see References 4, 5, and 6. The radium was inserted into the brain through a small hole, 2 to 4 mm. in diameter, drilled in the calvarium.

FIG. 1. The monkey before treatment, and the apparatus (puzzle-box) used in establishing motor habits. (For further reference see text.)

The larger doses of unfiltered radium emanation, used in the second method, were contained in glass tubes, 10 mm. long, 0.6 mm. in diameter, with walls about 0.2 mm. thick. These were thrust directly into the brain tissue, and a fine piece of surgical silk was tied at one end to facilitate their withdrawal.

The platinum capsule was 20 mm. long, 3 mm. in diameter, with walls 1 mm. thick. A stiff steel rod, fitted into the upper end of the capsule, served as a means of thrusting the applicator into the brain. This accomplished, the rod was removed, while a fine wire, also attached to the upper end of the applicator, was used in withdrawing the tube after the treatment.

The so-called "lead tray" that was used for the treatments of heavily filtered radium emanation, gave a filtration of 2 mm. of lead and 0.5 mm. of silver. The applicator was held at varying distances from the scalp, as will be described later. In treating the dogs a lead shield, 2 mm. thick, protected the parts of the head that one did not desire to treat. The radiation reached the brain mainly through a rectangular opening (2 cm. by 4 cm.), cut in the shield. The radium tubes were arranged over a correspondingly large area on the floor of the applicator.

The rats and guinea pigs were operated upon under light ether anesthesia. The rabbits and dogs were given subcutaneous morphine injections. One quarter grain was sufficient for a full-grown rabbit, while three quarters to one grain were used for the dogs, depending on the size of the animal. About one grain was given to a 15 kilo. dog. When the radium was inserted into the brain, a 1 per cent novocain solution was used as a local anesthesia in addition to the morphine. For the surface applications of heavily filtered radium, it was necessary to quiet the animals for from two and a half to five hours. In these cases, morphine alone was used.

A monkey was selected as a subject because it was thought that it might exhibit more delicate locomotor disturbances, and more especially defects in digital manipulations, than could possibly be detected in the case of dogs and the other animals. In order to obtain more accurate objective data than are generally given for this type of experimentation, certain motor habits were established before the brain was exposed to radiation. A time record was made of the learning process and notes were taken concerning the individual differences in behavior peculiar to the animal. The puzzle-box shown in

Figure 1 was used. At first the animal's daily task consisted in opening the door of the box, which would swing forward when a central catch, as shown in the illustration, was set at the vertical position. Its food, previously placed within, was then obtainable. When this task was learned the situation was complicated by the addition of the lower catch, and finally, when both of these could be manipulated at once, the higher latch was added. Ample opportunity was afforded the experimenter to study possible disturbances or variations in the several distinct motor habits that eventually became fixed in the animal's behavior.

EXPERIMENTAL RESULTS

1. *The effect of small amounts of unfiltered radium emanation upon brain tissue.*—The localized effect of radium destruction was the most marked feature of the method wherein the brain was radiated by small amounts of unfiltered radium emanation. In all cases the destroyed tissue was an elliptical solid, with a necrotic area in the center, in the immediate proximity of the radium tube. This necrotic area was about 5 mm. in diameter, and was surrounded by a zone, 2 to 3 mm. wide, showing brain cells in various stages of degeneration. In nearly all cases, the total area of well radiated tissue was about 1 c.c., generally exactly that amount, seldom less, and never but 1 to 2 mm. more in diameter. That this reaction was due to the radium emanation and not to the presence of the glass tube, or the traumatism incident to its insertion, was previously determined in a control experiment.[6]

A pronounced feature associated with these lesions was a leukocytic infiltration, which tended to wall off the radiated area from the normal brain tissue. This is well shown in Figure 2, and in this case the infiltration was due to polynuclear cells. The lesion was caused by an unfiltered tube of 1.2 mc. placed over the calvarium above the right cerebral region, and left there for forty days. The scalp immediately above the tube was destroyed over an area of 8 mm. by 10 mm. The brain lesion showed a central necrotic area, about 5 mm. in diameter, around which was a zone of polynuclear leukocytes, while beyond this was a broad region showing hyperemia and some pial edema. The ganglion cells near the necrotic zone showed marked hydropic degeneration

FIG. 2. High power view of a section of a rat's brain, showing the edge of a lesion in the superior portion of the right hemisphere, well localized by a marked area of leukocytic infiltration. A small glass tube, containing 1.2 millicuries of radium emanation was placed between the calvarium and the scalp, and left in place for thirty days. At the right is shown a portion of the area of necrosis, next the zone of leukocytes, and a wide area of hyperemia. (For further reference see text.)

and all the nuclei stained poorly. There were minute blood extravasations, with some increase in the small compact nuclei in this area, and the pia showed marked round-cell infiltration. The cells of the adjoining convolutions showed chromatic bodies that did not stain well. There was pericellular and perivascular edema.

The localized action of buried small doses of radium emanation is again shown in the lesion indicated in Figures 3, 4, and 5. A single tube of 1.1 mc. was inserted in the brain of a young dog on November 17, 1919, and was allowed to remain there permanently. During the following month the dog (here called dog A) showed no appar-

ent neurological disturbances, and at the end of thirty days it was killed and the brain placed in fixative. The gross examination of the brain showed a well circumscribed lesion, 15 mm. below the dorsal convexity, in the mesial gray matter of the cortex just superior to the corpus callosum (Fig. 4). Five millimeters below this level the ventral limits of the lesion extended through a portensity became less and less. The total amount of radium emanation was reduced, by a natural process of "decay," 16.5 per cent per day, and this was a continuous process. At the end of four days, the total amount was reduced to about one half.

Similar brain tissue reactions were obtained with other animals, rats, guinea pigs, and dogs, also treated with small doses of

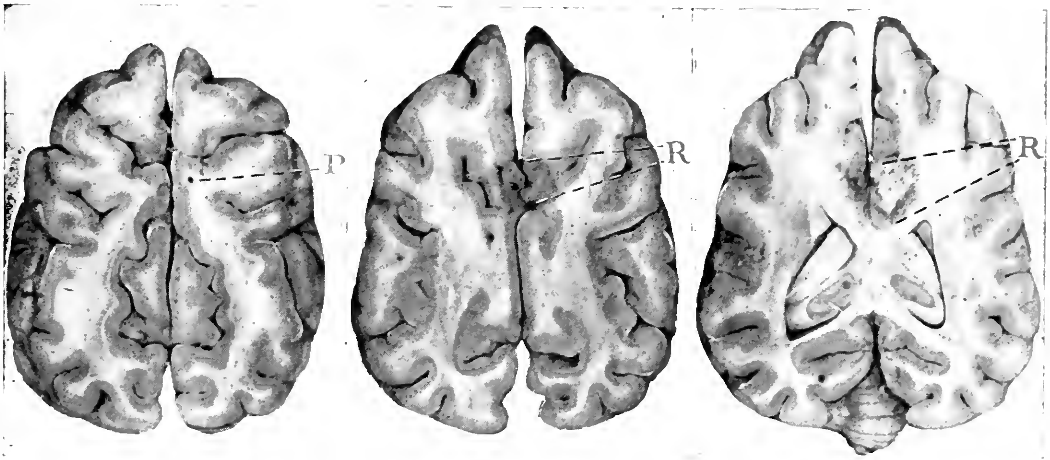

Figure 3. Figure 4. Figure 5.

Fig. 3. (P indicates point of insertion.) Section of the brain of dog A, 11 mm. below the surface, showing the point of insertion of the radium trocar. Fig. 4. (R indicates radiated area.) Section of the brain of dog A, 15 mm. below the surface, showing the lesion produced by 1.1 mc. of unfiltered radium emanation. Dose = 127 mc. hrs. Time = thirty days. Fig. 5. (R indicates radiated area.) Section of the brain of dog A, 20 mm. below the surface. The ventral limit of the lesion is about 2 mm. below this level.

tion of the genu of the corpus callosum, and on the right side involved a small part of the internal capsule (Fig. 5). The lesion was about 10 mm. in diameter, and was sharply marked off from the normal brain tissue surrounding it. Histological examination showed necrosis at the center surrounded by a zone about 2 mm. wide showing edema and destruction of nerve tissue.

The dose in the above case was 127 mc. hrs., and the lesion was produced by a relatively small amount of radium emanation acting over a comparatively long period. To understand the nature of this reaction, one must remember that at the time the radium emanation was placed in the brain it radiated the tissues with a maximum intensity, but during the following days the inunfiltered radium emanation. It was found from these experiments that a considerable amount of brain substance could be destroyed without producing apparent neurological disturbances. This matter will be discussed later.

II. *The effect of a comparatively large amount of unfiltered radium emanation upon brain tissue.*—A large amount of unfiltered radium emanation gave a much more extensive and intensive tissue reaction than any recorded in Section I. This was so although the dose in number of millicurie hours remained the same as that received by dog A, i.e., 127 mc. hrs. On March 22, 1920, at 4 P. M., a tube containing 255 mc. was inserted into the brain of an adult dog

(dog B) and left in place for thirty minutes (255 mc. for one half hour = 127 mc. hrs.). The tube was thrust into the brain through a hole in the calvarium. The following morning the dog showed signs of brain disturbances. It lived for four days and during that time there was a progressive development of a left hemiplegia (note the "foot drop" of the forward limb, and the abnormal position of the hind limb on the left side, as shown in Figure 6), with blindness of the left eye, and a pronounced tendency to turn to the right. At the end of four days the dog refused food, it became comatose, and as recovery appeared hopeless, it was killed by ether anesthesia.

FIG. 6. Photograph of dog B, four days after treatment with 255 millicuries of unfiltered radium emanation for thirty minutes. Dose = 127 mc. hrs. There is a left hemiplegia, and left eye blindness. (For further reference see text.)

A gross examination of the brain, 21 mm. below the dorsal convexity, showed a large, well circumscribed, hemorrhagic lesion, 17 by 18 mm. in diameter, involving a large portion of the right thalamus, extending from the region of the hippocampus to the inferior border of the section of the head of the caudate nucleus appearing at that level, and completely intersecting the fibers of the internal capsule (See Figures 7, 8, and 9). On microscopical examination the lesion

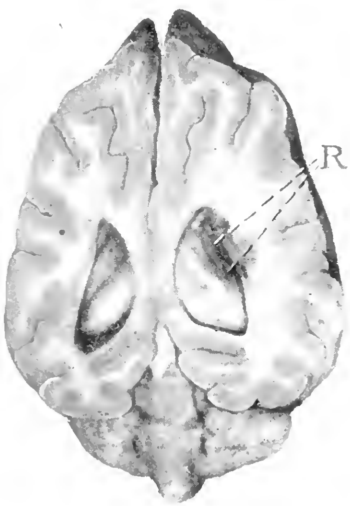

FIGURE 7.

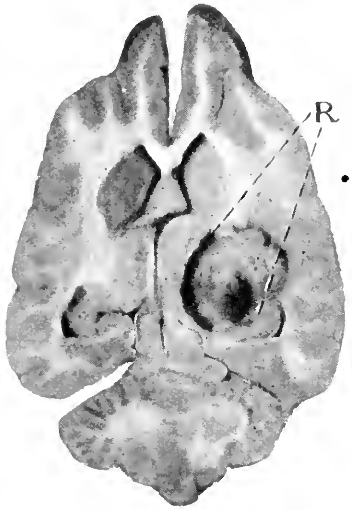

FIGURE 8.

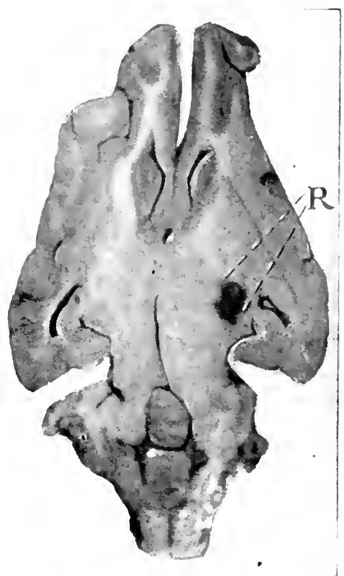

FIGURE 9.

FIG. 7. (R indicates radiated area.) Section of the brain of dog B, 13 mm. below the surface, showing the dorsal limits of a lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes. (For further reference see text.) FIG. 8. R indicates radiated area.) Section of the brain of dog B, 21 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes. FIG. 9. (R indicates radiated area.) Section of the brain of dog B, 28 mm. below the surface, showing the ventral limits of the lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes.

showed a central area of brain softening, 10 mm. in diameter, with extravasated blood, thrombosed blood-vessels with necrotic of polynuclear leukocytes, and a zone of hydropic degeneration of nerve tissue, while the ganglion cells for a considerable distance

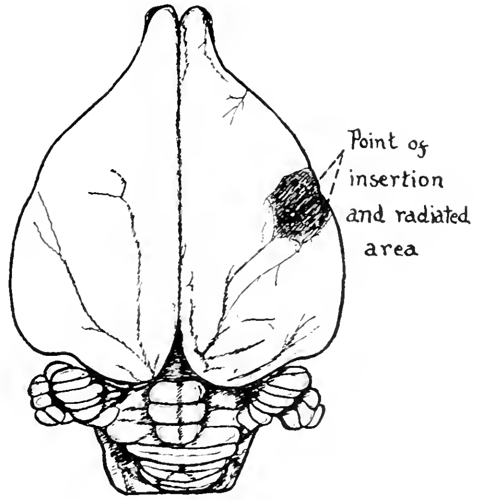

FIGURE 10.

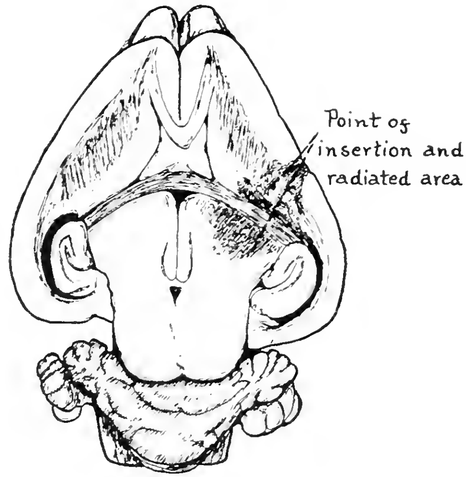

FIGURE 11

FIG. 10. Dorsal view of the brain of rabbit A, showing the lesion produced by 63.5 millicuries of unfiltered radium emanation for two hours. Dose = 127 mc. hrs. FIG. 11. Section of the brain of rabbit A, 8.5 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 63.5 millicuries of unfiltered radium emanation for two hours. Dose = 127 mc. hrs.

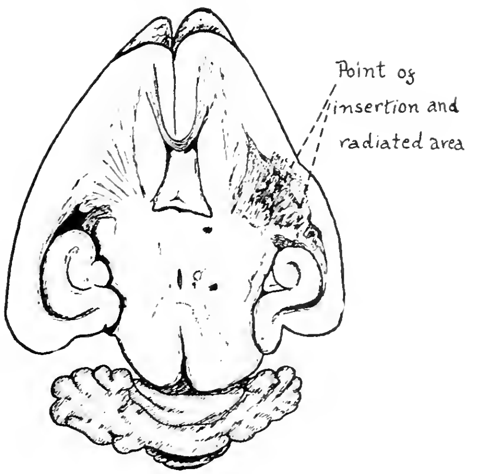

FIGURE 12.

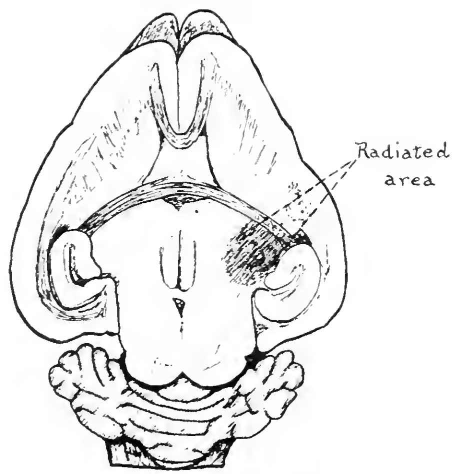

FIGURE 13.

FIG. 12. Section of the brain of rabbit B, 9.0 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 241 millicuries of unfiltered radium emanation for fifteen minutes Dose = 60.2 mc. hrs. FIG. 13. Section of the brain of rabbit C, 8 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 241 millicuries of unfiltered emanation for ten minutes. Dose = 40.1 mc. hrs.

walls, and granular necrotic brain tissue. The necrotic vessels, surrounded by hemorrhage, extended to the periphery of the area. About the lesion there was a concentration beyond this area showed a loss of chromatic bodies. In the velum interpositum there were hemorrhage and considerable leukocytic exudate.

The remaining tests with comparatively large doses of unfiltered radium emanation are given in Figures 10 to 13 inclusive. Three large adult rabbits were used, approximately the same region of the brain was treated in each case, and the same methods were employed as were used for dog B.

Rabbit A was treated with 63.5 mc. for two hours, this again being a dose of 127 mc. hrs. The treatment was completed at 5 P. M., and the animal was found dead early the next morning. The extent of the destruction of the cortex at the surface was 6 mm. by 8 mm., as is shown in Figure 10. Figure 11, sketched at a level 8.5 mm. below the surface of the brain, shows a lesion 12 mm. in its largest diameter, involving the fornix on the right side, the corpus striatum, the adjacent cortex, and mesially a portion of the thalamus. The type of degenerative tissue change was essentially similar to that reported for dog B, except that there is a much richer exudation of polynuclear leukocytes in the pia mater over a wide area of the surrounding tissue.

Since these experiments are largely concerned with the extent of tissue reaction in response to the intensity and duration of radiation, the two remaining animals, rabbits B and C, were treated with comparatively large amounts of radium emanation for very short periods, so that the number of millicurie hours, as compared with the amount received by rabbit A, was much less.

Rabbit B received 241 mc. of unfiltered radium emanation for fifteen minutes. The dose was 60.2 mc. hrs., about one half the dose for rabbit A. This animal also died during the following night. In this case the gross tissue change, as shown in Figure 12, covered an area 8 mm. by 10 mm. in diameter, at a level 9 mm. below the surface of the brain. The lesion at this level was largely confined to the corpus striatum, but it extended to the cortex above as a solid mass of degenerative tissue. The lesion was essentially similar to that of rabbit A.

The lesion shown in Figure 13 was produced by the same radium tube that was used in the above experiment, i.e., 241 mc., and it was left in the brain of rabbit C for ten minutes. This dose was 40.1 mc. hrs., and the animal, as in the other cases, died during the following night. The lesion, 8 mm. below the cortical surface, was largely confined to the angle between the hippocampus and the fornix. It extended dorsally to the cortex, and ventrally it involved a small portion of the right cerebral peduncle. It is interesting to note that in this case, although the number of millicurie hours was reduced to 40.1, the area of destroyed tissue was still 6 mm. by 8 mm. in diameter.

III. *The effect of inserting into the brain a comparatively large amount of filtered radium emanation.*—Dog C was a large adult female. A platinum capsule with walls 1 mm. thick, containing 218 mc., was inserted into the brain and left in place for thirty-five minutes. The dose was 127 mc. hrs. As a result of the treatment the dog showed no apparent neurological disturbances, and remained well and active for the following month. At the end of that time it was killed by ether anesthesia. Gross examination of the brain revealed a comparatively small lesion, situated in the region of the superior portion of the internal capsule on the right side, and not more than 3 mm. in diameter. The microscopical examination showed a focus of softened brain tissue, with an accumulation of Gluge's corpuscles, some blood pigment, and a few foreign body giant cells surrounded by a new growth of spindle cells. The whole section had a cicatricial appearance. For a considerable distance about this area there was an accumulation of many perivascular lymphocytes and plasma cells. The focus was 3 by 4 mm. in diameter.

IV. *The effect of radiating the brain with an external application of heavily filtered radium emanation.*— Dog D was a well-grown female, about one year old. After being quieted by morphine, its head was protected by a lead shield, save for a rectangular opening 20 mm. by 40 mm. in diameter, which permitted radiation to reach the left cerebral hemisphere. The shield was 2 mm.

thick. The "lead tray" previously described, containing 1965 mc. of radium emanation, was placed immediately over this opening and left there for two hours and twenty-five minutes. The dose was 4,000 mc. hrs. The total filter for the left cerebral region was 0.5 mm. of silver and 2 mm. of lead, and the distance was 2 mm. About fourteen days after the treatment a moderate radium dermatitis appeared over the treated area, which later was surrounded by a 10 mm. zone of alopecia. This area extended slightly beyond the midline of the head. No other symptoms were noted, and the dog remained well and active, showing no apparent neurological disturbances for a month after the treatment. At the end of that period it was killed by ether.

A gross examination of the brain showed nothing abnormal, save possibly a slight congestion of the cortical blood vessels. The microscopical examination showed no changes either in the brain substance or the pia. The ganglion cells appeared normal and stained well. The blood vessels in the subcortical fiber tracts were sheathed with 1 to 3 layers of plasma cells, and there was a little blood in some of the perivascular lymph sheaths.

In treating dog E the same applicator and shield were used, but the distance was increased to 50 mm. The treatment consisted of an exposure to 1800 mc. for five hours, the dose being 9,000 mc. hrs. A 50 mm. gauze pad kept the applicator at the proper distance, and tended to decrease the secondary radiation from the surrounding metal surfaces. The pad did not change the character of the radiation that reached the brain, but it served better to protect the scalp. The dog was well and active after the treatment, and showed no neurological disturbances. The scalp remained normal except for a very slight loss of hair. At the end of a month the dog was killed by ether anesthesia. The brain was apparently normal from a gross examination. Microscopical examination showed the pericellular nuclei in the gray matter apparently increased in number. The Nissl substance in the ganglia cells was indistinct. The pia was apparently normal, there was a slight increase in the perivascular nuclei, but no vascular changes were noticeable.

Tissues from the radiated portions of the brains of dogs D and E were treated by Marchi's stain and Sudan III, but no degenerations were found in either case.

The monkey, which was the last animal in the series, was treated with the "lead tray" containing 2406 mc. for five hours. The application was made over the left temporal region, at 10 mm. distance, but in this case the shield was not used. The left side of the brain was radiated because the animal invariably used its right hand in manipulating the catches. Ten millimeters of rubber served to reduce the secondary radiation. As in the other cases, the filter was 0.5 mm. of silver and 2 mm. of lead. The dose was 12,030 mc. hrs.

It was not until eight days after the treatment that any clinical symptoms appeared. First was noticed a huskiness of voice, accompanied on the tenth day by pronounced salivation, and a beginning erythema over the left side of the face. The animal at this time was somewhat inactive. Except that the animal suffered greatly from the effects of a severe radium burn of the face, no neurological symptoms were noted that could be definitely attributable to brain disturbances brought about by the radiation. However, on the nineteenth and twenty-third days after the treatment a temporary fine tremor of the front limbs appeared, but this condition was not seen at any other time, and later disappeared altogether.

There was no evidence to show that radiating the brain directly interfered with the retention of the motor habits that were established before treatment. The experiment was adjusted to show possible deficiency in the digital manipulations, but nothing abnormal was noted in this regard in the handling of the various catches in the post-radiation series. A few minor changes were noted in the method of approaching the task, but no clumsiness or asynergia was apparent in its execution.

Judging the permanence of retention of the habit by the average speed of its accomplishment, the results show that one cannot conclude that radiating the brain in this particular animal materially increased the time of the reaction. The records in the accompanying Table I show that when due consideration is given to the probable error attached to each average, there is very little difference between the performance in the last twenty trials before, and the twenty-four trials after the treatment. In fact, the last ten trials, the last of which was taken only two days before death, show a considerable quickening of the average performance, despite the fact that the general physical condition of the animal, due to the radium burn, was poor. The animal became comatose on the thirty-third day following the treatment, and died the next morning.

At autopsy the brain was found to be apparently normal, except for a certain amount of anemia of the smaller cortical blood-vessels of the left temporal region in the area which was directly exposed to the radiation. The relative appearance of the various aspects of the brain is shown in Figures 14 and 15. Careful microscopical examination of the portion of the brain directly beneath the radiated area revealed no definite degenerative changes.

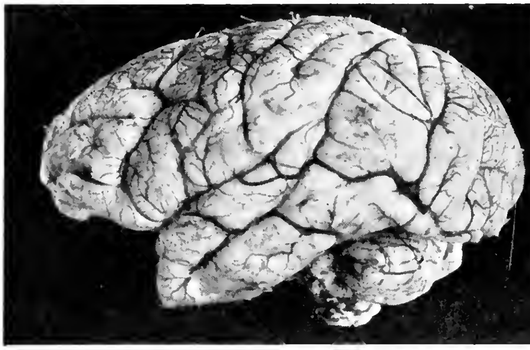

FIG. 14. Lateral view of the left side of the brain of a monkey after exposure to 2406 millicuries of heavily filtered radium emanation for five hours. Note the obliteration of the smaller cortical blood-vessels in the temporal region. (For further reference see text.)

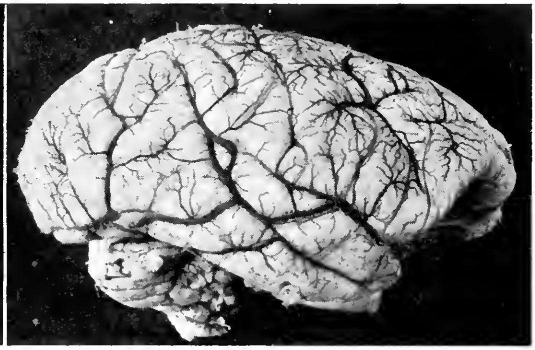

FIG. 15. Lateral view of the right side of the brain of the monkey after radiation.

TABLE I.

TIME AVERAGES FOR THE PERFORMANCE OF THE MONKEY IN THE BEHAVIOR TEST (PUZZLE-BOX REACTION)

	No. Secs.	*Probable Error*	*Mean Variation*
Average per trial for last 20 trials before treatment	26.4	± 3.0	15.9
Average per trial for 24 trials after treatment	38.8	± 6.4	36.2
Average per trial for first 14 trials after treatment	56.8	± 11.9	50.9
Average per trial for last 10 trials after treatment	13.6	± 1.4	4.9

DISCUSSION OF RESULTS AND SUMMARY

Danysz[7] (1903-1904) reported the presence of hemorrhages in the brain and spinal cord of mice exposed to radium. After 1 mg. of radium salt had been placed in con-

tact with the exposed dura mater of a rabbit for eight hours, hemorrhages were noted in the central nervous system, but no changes could be detected in the actual nerve elements.

Heineke[8] (1903) obtained similar results, and stated that deep hemorrhagic softening spread from the spot at which the radium tube had been applied.

Scholtz[9] (1904) and Okada[10] (1905) irradiated the sciatic nerves of young rabbits in the first case, and rabbits and frogs in the second, and although in both cases strong tissue reactions occurred, the nerves showed no alteration.

Obersteiner[11] (1905) treated the brains of white mice with capsules containing 10 and 50 mg. of radium bromide, and concluded that the irradiation had no specific effect on nervous tissue, and the derangements that occurred might be accounted for by the destruction of the small blood-vessels, which resulted in considerable hemorrhages in the brain substance.

Horsley and Finzi[12] (1911) applied a platinum tube, 0.5 mm. thick, incased in 1 mm. of rubber, and containing 55 mg. of radium bromide, to the precentral and postcentral gyri of the brains of monkeys. (On Rutherford's standard the amount of pure metallic radium was 22.7 mg.) Two animals received treatment for two and a half hours, and showed no disturbance at the end of twenty-six and thirty-one days when they were killed. Another animal was treated in three places over the brain with a tube containing the equivalent of 100 mg. of radium bromide, and it showed no disturbance up to the fifty-fourth day, when it also was killed. The writers noted in the meninges "endothelial proliferation of the walls of the blood-vessels, in some cases practically occluding the lumen." Punctiform hemorrhages were noted in the cortex, in one animal, as deeply as the fifth layer of the cortex. They conclude that "radium rays, from which the less penetrating beta rays have been filtered off, and employed in a strictly clinical procedure, exert no influence discoverable by present methods on the nerve tissue, but do cause notable changes in the blood-vessels."

Williamson, Brown, and Butler[3] applied 50 mg. of radium bromide over the motor area of the cortex of dogs. A platinum tube, with walls 0.4 mm. thick, was placed under the dura for four, six, twelve, and eighteen hours. Rubber was not used to absorb the secondary radiation from the platinum. None of the dogs showed disturbing symptoms after the application. The writers noted a 4 mm. area of necrosis beneath the tube, which showed thickening and hyalinization of the blood-vessels without rupture of their walls. Beyond this area, for a zone 1 mm. wide, was a region showing cells with evidences of degeneration, and ruptured blood-vessels producing hemorrhagic infiltration. The line of demarcation from this area to the surrounding normal brain tissue was sharp. There was no cellular infiltration, except from the hemorrhage, and no evidence of beginning repair. These investigators conclude that "the application of radium to the brain of the dog, under certain limitations as to time and strength, has a destructive action, but produces no clinical symptoms."

The writer's results confirm, in the main, the previous reports concerning the so-called resistance of nervous tissue to filtered radium. The additional information herein recorded is concerned with the localized beta-ray effect of small tubes containing small amounts of radium emanation, the more intense, extensive, and promptly destructive reaction following the insertion in the brain of comparatively large doses of unfiltered radium emanation, and finally, that the brain may be externally radiated, through both the scalp and skull, by large amounts of heavily filtered radium emanation, radiating from a comparatively large surface applicator, and the nervous tissue still may show no signs of degeneration.

In a previous paper[6] attention was called to the localized effect of buried tubes containing small amounts of radium emanation in various kinds of tissue, and it was noted that nervous tissue was no exception to this rule. The present experiment extended this

observation to different parts of the brain in various animals. In practically all cases the volume of degenerated tissue was one cubic centimeter, generally exactly that amount, seldom less, and hardly ever more than 1 to 2 mm. more in diameter. This localized reaction is probably due to three reacting factors: first, the dispersion of rays is increased the greater the distance from the source, so that the tissue in the immediate proximity of the tube receives the maximum intensity of radiation; second, the beta rays are largely absorbed by a few millimeters of tissue (see the recent work of Quimby[13] in this regard); and third, the inflammatory reaction of the surrounding tissue, leukocytosis, etc., also tends to localize the reaction.

The slow, localized brain tissue reaction, in response to radiations from small amounts of unfiltered radium emanation, gradually diminishing in strength, is usually associated with no neurological disturbances. This type of reaction, associated with unilateral brain destruction, may be such that compensatory adjustments have sufficient time to bring about apparently normal physiological reactions. These results are similar to the gamma-ray reactions recorded by Horsely and Finzi for monkeys, and Williamson, Brown and Butler for dogs.

There is an entirely different physiological and histological reaction associated with exposing the brain to comparatively large doses of unfiltered radium emanation. The intensity of radiation in the vicinity of the tube is greatly increased, hemorrhagic infiltration is extensive, and the entire process is so rapid that the adjustment of the organ as a whole is impossible and fatal terminations soon occur. Comparing the above results one may see that the physiological and histological reactions in response to a small amount of unfiltered radium emanation (mainly of beta-ray activity) acting over a comparatively long period, are not similar to an equal dose consisting of a much larger amount of radium emanation acting for a correspondingly short time.

Previous investigators have emphasized the local nerve tissue reaction due to gamma radiations from applicators placed on the surface of the brain. The results of the present experiments extend this observation to gamma radiation when acting beneath the cortex.

The final contribution of this paper deals with the radiation of the brain, through the scalp and skull, by heavily filtered radium emanation. Here again is emphasized the ability of nervous tissue to withstand a considerable amount of gamma-ray radiation. The applications were made as in a strictly clinical procedure, and the dose was as strong as those employed in the therapeutic treatment of certain types of cancer. Although the dose, in the case of the monkey, was increased to the limit of skin endurance, there still was no apparent physiological disturbance in brain function, and, except for an obliteration of certain of the smaller cortical blood vessels in the radiated area, no anatomical change was noted, and there was no apparent degeneration in the structure of the nervous tissue.

The behavior test, employed in a careful study of the animal's habit reactions before and after exposure of the brain to intense radiation, revealed no cerebral disturbance. The average daily time record, associated with the opening of a fairly complicated puzzle-box, was about the same after the treatment as it was before.

CONCLUSIONS

1. Of the four methods that have been tested, the application of heavily filtered radium emanation over the scalp may be considered a relatively safe procedure for the treatment of brain tumors.

2. The burying of small doses of unfiltered radium emanation (mainly beta-ray radiation) is also suggested as a favorable method of treating such growths.

3. The relatively sudden destruction produced by comparatively large doses of unfiltered radium emanation makes this

method unsafe for the treatment of brain tumors.

4. While the applicability of imbedding filtered radium emanation is still uncertain, it is possible that by using still larger doses than were employed in these experiments, and decreasing the filtration, this method may also be of use.

5. It was noted that nervous tissue was markedly resistant to gamma-ray radiation, and this reaction is probably associated with the relatively adult condition of the nerve cells.

6. The changes in the brain following radiation were largely due to the destructive action of radium emanation on the blood vessels.

7. There was a marked localized reaction, associated with a pronounced leukocytic infiltration, following the insertion of small doses of unfiltrated radium emanation in the normal brain. These lesions were especially interesting, because of the absence of neurological symptoms.

8. In the case of a monkey that received a strong dose of heavily filtered radium emanation over the brain, there was no subsequent loss of previously established motor habits.

The writer wishes to acknowledge his indebtedness to Dr. James Ewing for his advice concerning the pathological changes observed in the histological material, and to Dr. Beatrice Fairbanks for preparing and diagnosing sections from the brains of two of the dogs.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

CORRESPONDENCE

London, 24th June, 1921.

To the Editor:

Dear Sir: We have noticed with interest an article in the April number on "The Practical Application of the Sphere Gap to Roentgenography," by Dr. H. J. Ullmann. Since the early part of 1920 we have been advocating the use of sphere gap voltmeters measuring continuous or peak discharges up to 250,000 volts, as we have realized the great value of adding such a sphere gap voltmeter to every *x*-ray outfit.

The importance of measuring the voltage applied to an *x*-ray tube is becoming generally recognized, but the problem is not too easy with the high voltages that obtain in *x*-ray practice. The work of Peek and others has shown that a spark gap between spherical electrodes of equal size is a convenient and accurate means of measuring high voltages. The spark between points is now generally discredited for high voltages on account of its liability to inconsistency and its dependence on atmospheric conditions and frequency of discharge. By reason of its variable time-lag, its readings may on occasion be 300 or 400 per cent in error, in the case of high frequency steep impulses.

On the other hand, frequency and wave shape have no appreciable effect in the case of the sphere gap, and the effects of variation in the atmospheric conditions are well known, and can be readily corrected for.

The size of the spheres is important. A good rule is not to use a gap bigger than the diameter of either of the balls, though some latitude may be permitted in this direction. The main point is to avoid the break-down discharge being preceded by brush-discharge or corona, otherwise a pulsating discharge will, in general, give gap readings too high.

With the above precaution, a sphere gap is a reliable instrument capable of measuring voltages from say 10,000 volts to 500,000 to an accuracy of about 2 per cent.

The gap should not be exposed to any extraneous ionizing influence, such as an arc or an adjacent spark, nor should the gap be enclosed. The first spark is the one for which the reading should be taken. A continuous spark can readily be blown out by the mouth or other means, and so prevented from lengthening out when the gap is widened.

HOWARD C. HEAD, *Director.*
WATSON & SONS (Electro-Medical) LTD.

Atlanta, Ga., Aug. 17, 1921.

To the Editor:

I have noted with interest the instructive paper of Dr. W. O. Upson concerning transposed viscera, appearing in your July issue.

Within the last two years two cases have come under my observation. One, a fairly well-nourished man of forty-four, who suffered from typical duodenal ulcer symptoms, and who showed definite pathology of the duodenal cap, exhibited a complete transposition of both the thoracic and abdominal organs. Two of his brothers and two sisters were fluoroscoped, but were normal.

The other was a young and husky man, who was applying for entrance in the navy. The examining physician discovered that his heart was on the right side and sent him to me for examination. He, too, showed a complete transposition of his thoracic and abdominal organs. The latter individual was a fine specimen of physical manhood, and insisted that he had never suffered from any illness whatever from his youth to the present.

GEO. M. NILES, M.D.

BOOK REVIEWS

The Roentgen Diagnosis of Diseases of the Alimentary Canal. By Russell D. Carman, m.d., Head of Section on Roentgenology in the Division of Medicine, Mayo Clinic, and Professor of Roentgenology (Mayo Foundation) Graduate School of Medicine, University of Minnesota. Second Edition thoroughly revised. Containing 676 pages with 626 original illustrations. Price $8.50. W. B. Saunders Company, Philadelphia, 1920.

This excellent book has achieved its second edition. It carries an additional 98 pages, new illustrations to the number of 122, and 2 new chapters. One of the chapters is upon "Hour-Glass Stomach" and the other "A Chronological Abstract of the Published Work of Pneumoperitoneal Diagnosis of Abdominal Lesions."

The book is printed upon rather thin paper and carries the 676 pages in an easily handled volume which is excellently bound in a flexible back.

There is no doubting the fact that this text book is the most thorough exposition of abdominal roentgenology in any language. There is sufficient new and revised material to demand the re-purchase of this edition by those who have appreciated the first edition.

E. H. Skinner.

Medical Electricity, Roentgen Rays, and Radium, with a Practical Chapter on Phototherapy, by Sinclair Tousey, a.m., m.d., Consulting Surgeon St. Bartholomew's Clinic, New York City. Third edition, thoroughly revised and greatly enlarged, containing 1337 pages, 861 practical illustrations and 16 in colors. Price $10.00. W. D. Saunders Company, Philadelphia, 1921.

Tousey truly states in the preface that it is practically impossible to write a book on electricity which will be up to date, because of the many rapid changes.

This book contains a great deal of valuable information concerning electricity in the numerous forms which are applicable to medicine, devoting chapters to static and dynamic electricity, electricity occurring in animals and plants, the physiological effects of electricity, electro-pathology, electro-diagnosis and electro-therapy.

In addition he devotes a chapter to physical reconstruction after war injuries, in which he mentions the testing of nerve injuries, nerve testing at time of operation, and electro-treatment of nerve injuries. He then discusses the physiological and therapeutic effects of the electro-magnets, electricity in disease of the nervous system from a diagnostic and therapeutic standpoint, and at the end of this chapter he takes up the physiological causes of death by electricity. The chapters on high frequency currents are very comprehensive. He devotes 546 pages, with numerous illustrations, to the roentgen ray, approaching it from the standpoint of physics, then the localization of foreign bodies, roentgenography, development of roentgenograms, and fluoroscopy. He then describes his technique for roentgenography of all portions of the body. He writes at some length on roentgen therapy, including his technique. The last forty pages are devoted entirely to radium—radium activity, radiochemical, physiological and pathological effects, and therapeutic uses. There is a very complete and extensive index.

The book is valuable, in that it serves as an excellent reference book.

W. W. Belden.

TRANSLATIONS & ABSTRACTS

The Protection of Roentgenologic Workers. (London Letter of the *J. Am. M. Assn.*, xxvii, No. 1.)

The committee for the protection of roentgenologists, which was announced in a previous letters (The Journal, April 23, 1921, p. 1181), has been formed. The chairman is Sir Humphry Rolleston. The members are Sir Archibald Reid, radiologist to St. Thomas' Hospital; Dr. Robert Knox, radiologist to King's College Hospital and the Cancer Hospital (representing the British Association for the Advancement of Radiology and Physiotherapy); Dr. S. Gilbert Scott, radiologist to the London Hospital; Dr. Stanley Melville, radiologist to St. George's and to the Brompton Chest hospitals (representing the Electrotherapeutic Section of the Royal Society of Medicine); Dr. Harrison Orton, radiologist to St. Mary's Hospital; Mr. Cuthbert Andrewes (representing the Röntgen Society); Prof. S. Russ, physicist to the Middlesex Hospital (representing the Institute of Physics); Dr. G. W. C. Kaye (representing the National Physical Laboratory), and Dr. J. C. Mottram, pathologist to the Radium Institute. The committee held a preliminary meeting and appointed a sub-committee to draw up a statement, to be issued as a leaflet, on the means for the protection of the workers, giving advice as to the position of roentgen-ray rooms, their ventilation and cubic space, and on the need for making and observing rules governing the hours of work, outdoor exercise and holidays of workers. The committee intends to collect data on the effect of irradiation with particular reference to protection; to carry out special research; to act in a consultative and, possibly, advisory capacity, and to publish reports from time to time.

Funk, Elmer H. Malignant Diseases of the Lung. (*Med. Clin. N. Am.*, March, 1920, p. 1197.)

New growths are not frequent in the lung, and are often mistaken for pulmonary tuberculosis. "Among 1200 patients sent into the wards of the chest department of the Jefferson Hospital with the diagnosis of advanced tuberculosis, 72 or 6 per cent were incorrectly diagnosed and of this number 5 were instances of malignant disease of the lung." Among 551 postmortem cases collected by Ash from different tubercular institutions, 61 were non-tubercular; 11 per cent of these were primary neoplasms. Passler from a total of 1000 autopsies found 16 primary carcinoma, and 5 primary sarcoma of the lung; Seydel, 184 malignant tumors of lung and pleura from 10,829 autopsies; 16.8 per cent were primary, 83.2 per cent secondary. Adler, 374 cases of primary carcinoma, 90 were sarcoma. "Secondary carcinoma may arise from an initial focus in the abdomen or from extension of a mammary, esophageal or thyroid tumor. Metastatic sarcoma most often originates from a primary growth in one of the long bones."

As yet there is no known primary cause of malignant tumors. For several years trauma in various forms has often been observed to precede the malignant disease. Irritation, such as dust, etc., has also been thought to play a part, and may account for the predominance of the disease.

The symptoms may be latent. However, in most instances, especially in the primary growths, there are definite signs and symptoms. These depend upon the size, origin, situation and rate of growth of the tumor. The local symptoms are shortness of breath, cough, pain and pressure effects. The general symptoms are progressive weakness, loss of weight, secondary anemia, etc.

Roy G. Giles.

Knox, R., London. *X*-Rays in the Diagnosis of Tumors of the Thorax. (*Brit. M. J.*, 1920, ii, 392-395.)

Knox classifies tumors of the thorax as: (1) intrathoracic; (2) extrathoracic; (3) both extra- and intrathoracic. Benign and malignant conditions of the skin, soft parts and bony parts, capable of casting a moderately dense shadow on the negative, are described. Also those of the internal organs of the thorax, mediastinum, heart and pericardium.

The exact determination of origin and site of tumors of the thorax will always be difficult and at times impossible. The majority of intrathoracic tumors, however, arise from the mediastinum. Broadly speaking, an extension out-

ward from the mediastinum will indicate the presence of a tumor, excluding the benign form tumor, such as aneurysm, hydatid cyst. The cause of such shadows in the order of their frequency will be found to be tuberculosis, carcinoma, and sarcoma.

Tuberculosis may give rise to very definite enlargement of the hilus shadows. Tuberculosis of the root glands and mediastinum of long standing is accompanied by degenerative changes.

Carcinoma, though rarely primary, is probably the most common of the primary neoplasms. It is not infrequently secondary. The history is important. The median shadow is nearly obliterated. There is frequent involvement of pleura and very little of lung left. It is often unilateral.

Sarcoma may be primary or secondary. It usually arises in the mediastinum and frequently from the thymus gland, and the edges are irregular.

Secondary sarcoma are common. They show large bulging shadows distorting the larger shadows of the structures in that region. The masses are larger; the density and the edges are more uniform than carcinoma and the nodules are not so numerous.

Syphilis occasionally may involve the lung or bronchi, occurring in two forms, interstitial and gumma.

Tumors arising in mediastinum are prone to give shadows similar to those of an aneurysm, endothelioma or sarcoma. The one differential point of value is the character of the pulsation observed in the tumors. Rarely aneurysm and tumors may occur in the same case.

R. G. G.

MAYO, CHARLES H. The Thyroid and its Diseases. (*Surg., Gynec. & Obst.*, March, 1921.)

The work of Kendall has resulted in explaining the chemical nature of the secretion of the thyroid. The present standardizing of the effect of the thyroid secretion on metabolism is largely due to the work of Plummer, aided by Boothby and Sandiford. The latter's reports are based on about 18,000 metabolic tests. They not only confirmed that hypofunction of the thyroid lowers the metabolic rate and hyperfunction raises it, but by using Kendall's pure thyroxin they have definitely ascertained the amount of thyroxin in the body, the amount normally in the gland, the amount necessary to bring a hypothyroidism to normal and the amount used up each day by the body.

It appears that the thyroid secretion makes available the energy of the cells of the body. This gland enables the individual to develop an available, active, iodinized secretion from the iodides of the food.

Iodine is notably deficient in the thyroid gland in exopthalmic goiter and is variable in the gland of adenoma with hyperthyroidism. The ultimate cause, however, of hyperthyroidism is still elusive. It may be in the chemistry of infection, toxemia produced within the gland or at a distant focus, or a chemical stimulant. Plummer has shown that the condition resembling exopthalmic goiter and known as pseudo-Graves' Disease, etc., is really hyperthyroidism due to adenoma.

One type of hyperthyroidism occurs in goiters of long standing, fourteen to twenty years, and is not accompanied by exopthalmos. The average age of these patients on appearance of hyperthyroidism is forty-three and their average age at operation is forty-eight. In exopthalmic goiter the average age is thirty-six years. Diagnosis can usually be made from the signs and symptoms and determination of the basal metabolic rate. The lymphocyte changes noted by Kocher are not reliable. Epinephrin injections recommended by Goetsch are likely to be misleading and may produce dangerous reactions.

The average age of patients at operation is between thirty-one and thirty-six, but he has seen a few cases between five and ten and a few between fifty and sixty.

The treatment in the adolescent period of simple goiters that do not spontaneously disappear is iodine, thyroid secretion, or thyroid products.

Operation is advised at any age in cases of round encapsulated adenoma causing distress. Partial removal of both lobes with removal of isthmus is performed for goiter of long standing or one resisting treatment.

Cancer of the thyroid is rare. The rapidly growing hard gland if smooth and even is probably due to hemorrhage in the gland structure. A hard symmetrical small gland that is not exopthalmic is possibly tuberculous.

Operations in the early stage of exophthalmic goiter should be as safe as those in simple goiter. Patients with exophthalmic goiter pass

through exacerbations and remissions; during exacerbations they should be medical and surgical patients, and if necessary treated by ligation, x-rays, hot water injections, and rest.

A patient with about plus 66 metabolic rate who has survived a recent exacerbation is a better surgical risk than one with rate of plus 46 who is on the rising wave of exacerbation. With x-ray treatment remission may occur just as it occurs without treatment or with several other methods of treatment. The writer's experience has been failure or but temporary benefit from x-ray treatment. It is possible that x-ray treatment may destroy the gland and produce hypothyroidism. He states that it is difficult to regulate the dosage and that its use adds to the difficulties of operation. He hopes that radiotherapy may be developed into a safe and effective method of securing a cure or relief in preparation for surgery.

A. C. C.

Case, James T. Surgical Physiology and Pathology of the Colon from the X-Ray Standpoint. (*N. York State J. M.*, xxi, No. 5,)

The paper is confined to a study of colonic peristalsis under normal and pathological conditions, and to the diagnostic and operative errors into which one may be led if unaware of the changing appearance of the colonic shadow during peristalsis. Emphasis is laid upon the prolonged stay of food residues in cecum and proximal colon, right-sided pain, distention and fullness suggesting appendiceal involvement, due to some obstructing organic or functional lesion in the distal colon or rectum, and to the importance of studying the entire colon, including pelvic loop and rectum, before accepting as the explanation of right-sided pain such rare lesions as adhesions of the terminal ileum or cecum, fixation of the appendix, so-called Jackson's membrane, hepatocolic bands, or ptosis of the transverse colon.

The outline of the normal colon is variable and ever changing. On palpation under the fluoroscopic screen the mobility of all parts of the colon can be demonstrated. The position and shape of the transverse colon is especially variable, undergoing a turning snakelike movement and suffering considerable dislocation without propulsion of its contents. Surgical procedure which aims to fix this portion of the bowel is discredited as interfering with the normal movement.

The prevailing movement in the proximal colon is antiperistaltic, tending to retain material in the cecum. The distal colon has as its characteristic activity a churning and onward movement. Haustral churning occurs constantly in the distal colon. The principal propulsive movement of the colon is the spontaneous large contraction activity to which the term "spontaneous mass movements" is applied. The bowel outline suddenly loses its haustral markings and takes the shape of an ovoid elongated sausage-shaped mass with smooth edges, rounded to the ends. This mass at once begins to move at about twice the rate of a peristaltic wave in the stomach, the rate and distance traversed varying according to the case. When it comes to rest the mass resumes its haustral markings.

During and following the opaque enema one frequently sees a large ring constriction passing along the colon distalwards and sometimes in the antiperistaltic direction.

These various phenomena may lead to diagnostic errors:

1. Pseudo-filling defects due to peristaltic activities simulating the defect produced by neoplasm.

2. Proximal colon stasis, especially cecal stasis due to exaggerated antiperistalsis which may be incorrectly attributed to membraniform or band adhesions involving the cecum, ascending colon or hepatic flexure, or the supposed prolapsus of the transverse colon.

3. A point of arrest in the transverse colon just proximal to the midline which may be erroneously attributed to organic obstruction.

The evidence obtained by x-ray study constitutes only one part of the medical examination of the patient, and should be interpreted in the light of the history and other physical and laboratory findings.

L. R. Sante.

Hawes, John B., 2d. Broncho-Esophageal Fistula and Traction Diverticulum. (*Am. J. M. Sc.*, June, 1921, clxi, No. 6, 791.)

Broncho-esophageal fistula is a rare condition in itself but traction-diverticulum is even more so. Traction diverticula are situated in

the anterior wall of the esophagus near the bifurcation of the trachea and result usually from the extension of inflammatory lesions of adjacent lymph glands with adhesions and subsequent cicatricial contraction by which the wall of the esophagus is drawn out. The diagnosis is readily made with opaque meal and x-ray examination. The condition may be suspected clinically but usually a fluoroscopic examination is necessary to confirm the diagnosis. One case of ordinary broncho-esophageal fistula following a long abscess and one of true traction diverticulum are described.

Case 1. Pulmonary symptoms continued for eleven months after pneumonia. A consolidation of the right lung with abscess formation was demonstrated radiographically. Soon after this examination the patient began coughing up large amounts of pus which occasionally was blood-streaked. He was operated, ribs resected and the abscess drained. One week later particles of food taken by mouth were recovered from the chest wound, and the x-ray examination definitely demonstrated a broncho-esophageal fistula. The discharge of material from the wound gradually lessened until it healed spontaneously about two months later.

Case 2. The onset of the trouble followed an attack of influenza in 1916. After several months' illness the patient had a large pulmonary hemorrhage. Following this she suffered from hemorrhages for the next three years, being very nervous, prostrated and much under weight. Physical examination at that time showed no evidence of abnormality except in the lungs. There was fairly definite evidence of an old tuberculosis in the right middle and upper lobes. An increase in peribronchial markings was present especially in the region of the middle lobe, and near the mid portion of the lung near the hilus a well-defined cavity was present. There was an associated interlobar thickening of the pleura. This diagnosis of tuberculosis was made in spite of the repeated negative sputum examinations. Sometime more than a year later the patient complained of small particles of food being coughed up in the sputum several hours after ingestion. X-ray examinations showed that while a large amount of the barium meal entered the stomach through the esophagus, a small portion remained in a shelf-like ridge over the lower end of the esophagus and part of the barium went into the cavity in the right lung. For six months following the barium meal only one slight hemorrhage occurred; this was a much longer period than had ever elapsed before without a hemorrhage.

The impressions that come from this case have convinced the writer that all cases of pulmonary hemorrhage in which repeated sputum examinations are negative should be studied closely for other causes. That foreign material may enter the lung with impunity and cause no serious damage is quite evident.

L. R. S.

Weibel. Vienna. Treatment of Cancer of the Uterus with the Symmetry Apparatus. (*Wien. klin. Wchnschr.*, June 2, 1921.)

This apparatus was devised by Wintz and Baumeister of Erlangen and has been tested in the II Gynecological Clinic at Vienna. Since the autumn of 1920 nine operable and six inoperable cases of cancer of the cervix have been treated. Of the first series three seem to be complete cures, although a biopsy of the tumor site shows a dubious condition of the epithelium. A fourth is on the way to recovery, while of the other five some are refractory to treatment, and others of too recent date to be discussed. Of the six operable cases one half are doing excellently. In discussion Neu-Wirth expressed the opinion that the symmetry apparatus had been thrust too far in the foreground. Irrespective of what apparatus is used the same results may be obtained if the tension, hardness of tube and filtration are the same in all. He enumerates a number of apparatus on the market which give equal results under the same conditions. A good operator will get the desired deep action from any one of them. The symmetry apparatus simply has a big advertising campaign behind it. One is not called on to advertise some manufacturer but simply to mention the tension, dose, filtration, etc. Latzko would invert the usual recommendation of abdominal radical operation for advanced, and vaginal for beginning cancer of the cervix. By doing the radical operation in the beginning case he would expect a very low operative mortality.

The advanced case he would treat by radiation with selected use of the amplified vaginal operation under local anesthesia. He endorses the Erlanger technique.

Birch-Hirschfield. Lesions Produced in the Human Eye by Roentgen Rays. (*Ztschr. f. Augenheilkunde,* 1921, xlv, 199.)

The question of the action of the *x*-ray on the eye is highly practical because this resource is beginning to be used in such affections as glioma of the retina and sarcoma of the choroid. Many have affirmed that intense radiation is harmless to the normal eye. The author, however, showed some years ago that this statement is too optimistic. Alterations may take place in the episcleral vessels, iris and retina and endothelium of the cornea. Recently his early labors have been fortified by results seen in two new cases which are the subject of the present paper. In the first, a man of twenty-eight, who had lost an eye in childhood through traumatism, had recently noted diminished vision in the remaining eye. Examination showed the presence of a tumor of the choriod. During ten days the patient received 600 Fürstenau units with a Coolidge tube, with a 3 mm. aluminum filter. Superficial opacities of the cornea and conjunctival injection resulted, which disappeared shortly. A second session the following month was followed by photophobia, lacrimation and pain. The skin of the eyelids was inflamed, the eyelashes dropped out, and a multitude of punctiform opacities appeared in the cornea, having originated in the epithelium penetrating deeply into the stroma. The conjunctiva was much injected and the episcleral vessels showed alternate contraction and dilatation. The iris and lens seemed normal. While regression was in evidence by the third week, some months elapsed before conditions became quite normal. A third session was undertaken after all reaction symptoms had subsided, with similar consequences. The tumor was arrested in its growth and reduced in size. In the second case the affected eye was sound and had been exposed to the rays without any protection, in connection with the radiation of an epitheloma of the upper eyelid. Five treatments were given during a year, each lasting forty-five minutes, without the production of any reactive changes in the eye. However, two weeks after radiation there were headache and fever, and after each consecutive session progressive intensification of these symptoms with corresponding diminution of vision. The tumor disappeared but the bulbus oculi was left edematous, with dilated and tortuous vessels, and there were both superficial and deep turbidity of the cornea, the pupil dilated and the anterior chamber shallow. Intra-ocular tension was 40 mm., vision nil. The pains in the eye did not yield to miotics and it became necessary to enucleate. The papilla was found to be excavated and there were minute hemorrhages in the retina. The condition was pronounced to be glaucoma. Since the *x*-rays have recently been recommended for this affection the experience of the author appears to show that this advice is premature unless perhaps vision is already lost.

Menard and Postel and Contremoulins. Dangers of Radiography to Third Persons. (*Presse méd.,* May 11, 1921, xxix, 38.)

Menard and Postel mention in their article the danger to which the medical men who are permanently in charge of *x*-ray laboratories are exposed. They are constantly exposed to the rays, and to protect them it is customary to place the tube in a capsule which absorbs the rays, the absorptive power of which varies with the potency of the ray to be used. In the most powerful French installation the tube is placed in a large capsule of special make which allows a filtration of only 36 millionths of the initial intensity. Contremoulin believes that *x*-rays may be propagated to a considerable distance and still preserve their heterogenous character. He showed on April 25th, before the Academy of Sciences, teleradiographs taken at a distance of from 40 to 80 meters with a Coolidge tube and with a spark length of 17 cm. The clear definition and marked contrast of these plates were surprising. Rays traversing this distance are readily absorbed and must in consequence exert a biological action. The author, disbelieving in the impermeability of partitions, placed the tube at a distance of 15 meters from a brick and stone wall 50 cm. thick, behind which he placed a sensitive plate. Four hours later the plate was completely fogged. If such results can be obtained with the softer rays used in radiography and of medium intensity, one should be alarmed at the thought of the effect of the 200,000 volts used in deep radiography in some French installations.

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AN UNUSUAL CASE OF PULMONARY NEOPLASM*

By J. S. PRITCHARD, M.D.

Department of Diseases of the Chest, Battle Creek Sanitarium

BATTLE CREEK, MICHIGAN

ON June, 24, 1919, a student nurse, single, age twenty-three, was referred to my department for a chest examination on account of cough and blood-streaked sputum, associated with afternoon temperature of 100° to 101° and pulse of 96 to 108. These symptoms had existed for the past ten days.

Prior to the above history the patient had always been well except for the usual diseases of childhood and two abortive attacks of what simulated appendicitis. Nineteen months prior to the present indisposition the patient was carefully examined before entering the Nurses' Training School, which showed the following results:

Family History.—One brother had tuberculosis of the hip and made a satisfactory arrest.

General Condition.—Height 5 feet, 7 inches, weight 125 pounds, temperature 98°, pulse 84. Well developed, reflexes normal. No glandular enlargement; no abdominal tenderness. Pelvic examination revealed no abnormality. In the physical examination of the chest no cardiac or pulmonary irregularities were noted.

Fluoroscopic study of the chest revealed no abnormal diaphragmatic or cardiac irregularities in size, shape or movements, while the hilar shadows were reasonably normal.

Laboratory Findings.—Urine negative. Red blood count 3,800,000. Hemoglobin 85. White blood count 8,600. Wassermann negative. No respiratory symptoms.

The present symptoms, which occurred nineteen months after the original examination, were rather abrupt in onset, except that for the past two or three months the patient had noticed a slight tendency to cough. This symptom was often associated with what the patient described as "wheezes" in the throat. For the past ten days a slight cough, accompanied with some blood-tinged expectoration and an afternoon temperature of 99.2° to 100° F., had been present.

Physical examination of the chest revealed moist râles over the front and back of the right hilum. Fluoroscopic study showed an enlarged right lung-root shadow. Stereo plates revealed a small, distinct, clean-cut, rounded shadow in the upper part of the right lung root. This shadow measured 3.5 cm. in width and was spheroidal in shape (Fig. 1). Sputum contained no acid-fast bacilli or elastic tissue. Wassermann negative. Complement fixation test for T.B. negative. No leukocytosis or eosinophilia.

The patient was placed on absolute rest treatment and all symptoms subsided rapidly, entirely disappearing in two weeks or approximately four weeks from the appear-

*Report of a case presented before the Kent County Medical Society, Grand Rapids, Mich., April 13, 1921.

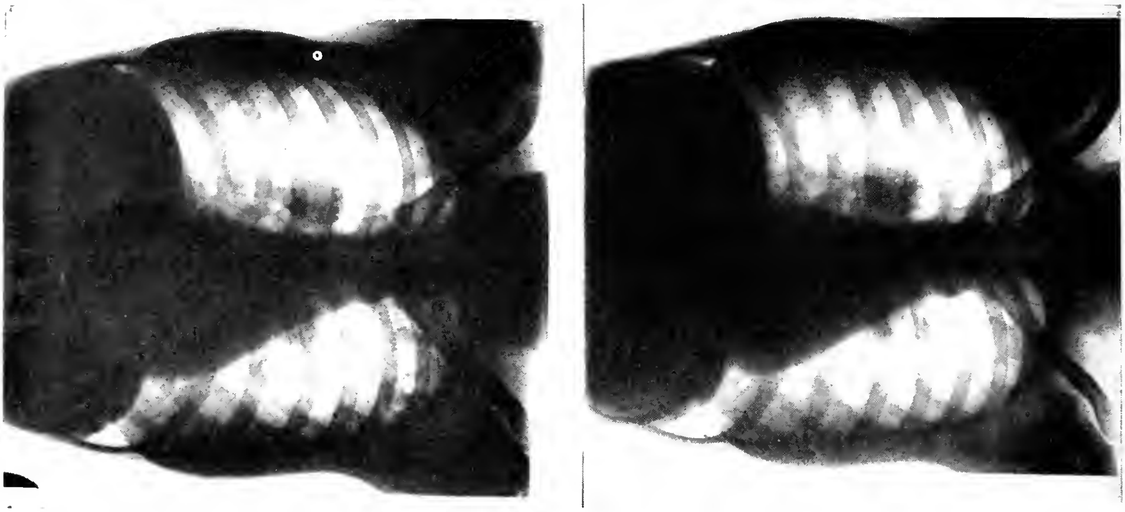


Fig. 1. Stereo plates showing a small rounded sh dow in the upper part of the right lung root.

ance of the first symptoms. The patient resumed her duties as pupil-nurse and worked steadily without interruption or indisposition, except for a slight unproductive cough, until April 7, 1920, a period of nearly ten months, when she had a recurrence of her former symptoms. These again disappeared after ten days' rest in bed. Stereo plates at this time showed that the right hilar shadow had about doubled in size ($7 \times 7\frac{1}{4}$ cm.; Fig. 2). A few sibilant râles were heard over the corresponding surface area in front. No leukocytosis. No eosinophilia. Complement fixation for T.B. negative. Complement fixation with Wineberg's antigen for echinococcic infection negative. Wassermann negative. No acid-fast bacilli were found in the sputum.

On July 2, 1920, the patient resumed her duties and remained free from symptoms and apparently well, except for a slight cough, for the next ten weeks. A moderate hemoptysis occurred a few nights later, followed by a decided rise in temperature (104° F.). Three weeks' rest in bed resulted in the disappearance of the symptoms, and

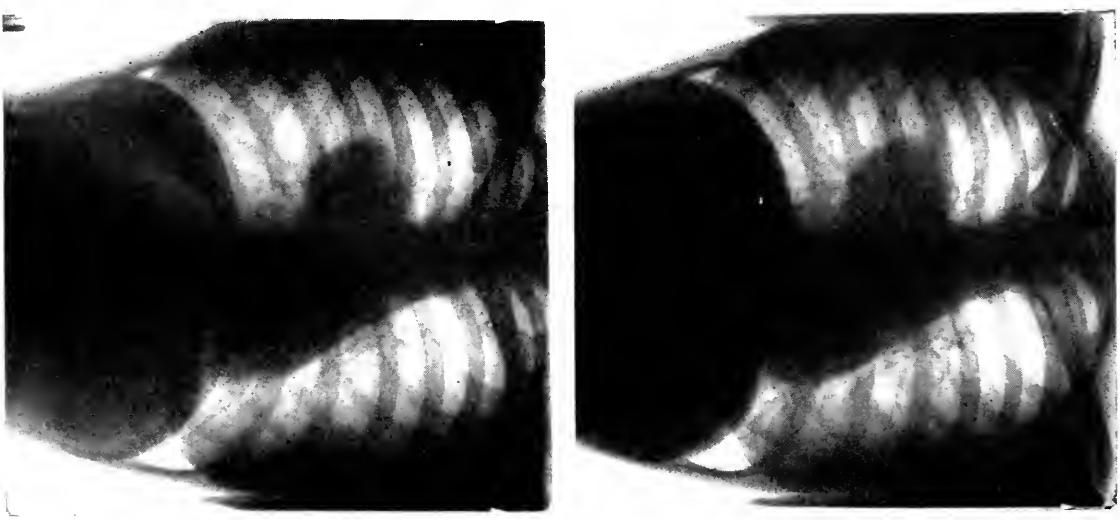


Fig. 2. Stereo plates taken ten months later, showing increase in the abnormal shadow.

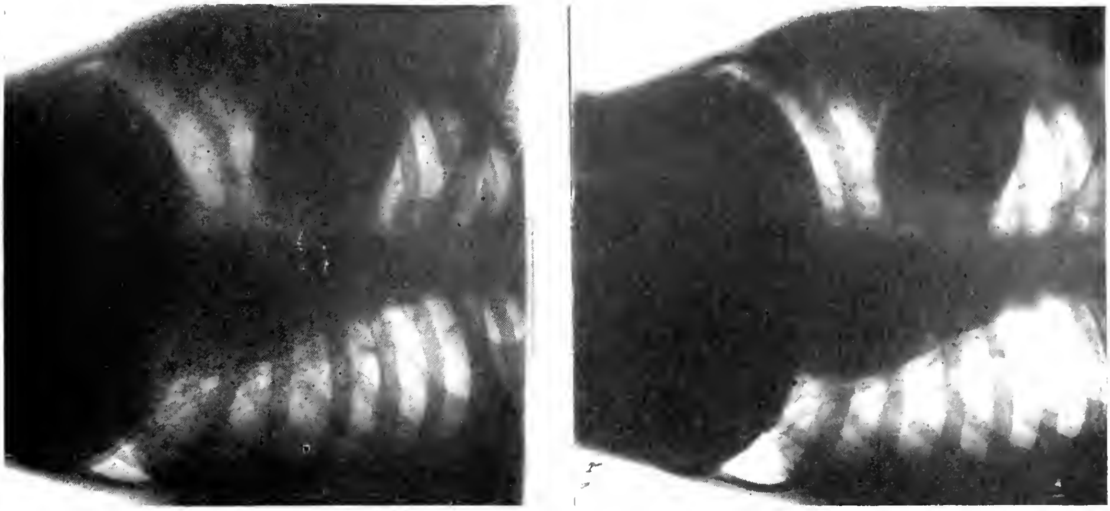


FIG. 3. Stereo plates taken ten weeks later, showing an extension of the pathology to the pleura.

another investigation at this time showed a definite increase in the thoracic growth, it now measuring 12 cm. across and 10 cm. on a vertical plane and extending to the pleura (Fig. 3). The râles had correspondingly increased in area.

After the third attack, the patient went home and rested for a while, returning about the middle of September, 1920. Two months later she was again referred to me on account of an increased pulse rate, fever and expectoration. An examination showed the pulmonary pathology had increased to such an extent as to occupy most of the right thorax except the apex and the costophrenic angle (Fig. 4).

After some subsidence in the clinical symptoms, the patient was sent to Dr. Emil Beck of Chicago for an opinion relative to surgical interference.

Up to this time, sixteen months after the initial attack, we were not able to make a diagnosis, but gave the following opinion: "We are unable to determine the type of chest pathology but advise surgical interference." Dr. Beck carefully studied the case

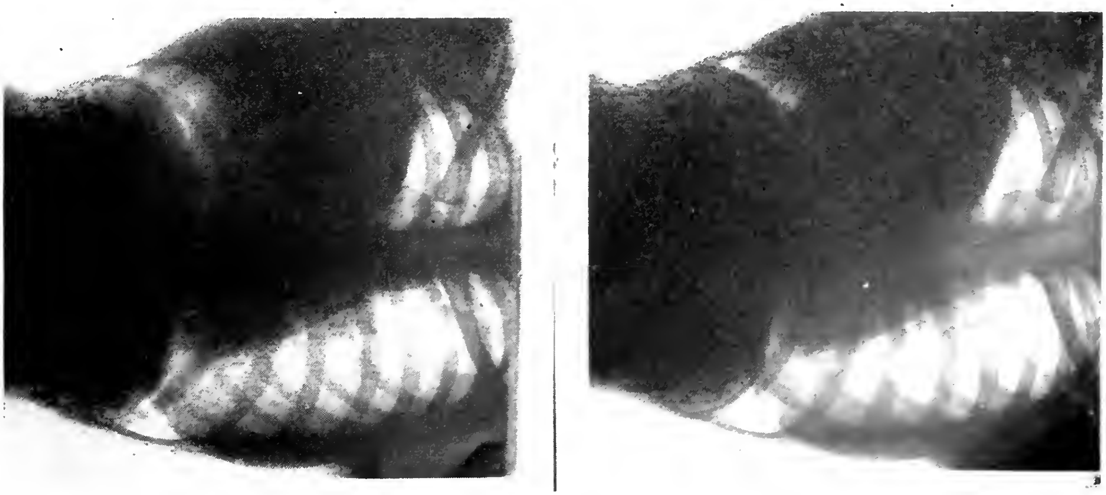


FIG. 4. These plates were taken eight weeks later or about fifteen months after the first roentgen-ray findings (Fig. 1).

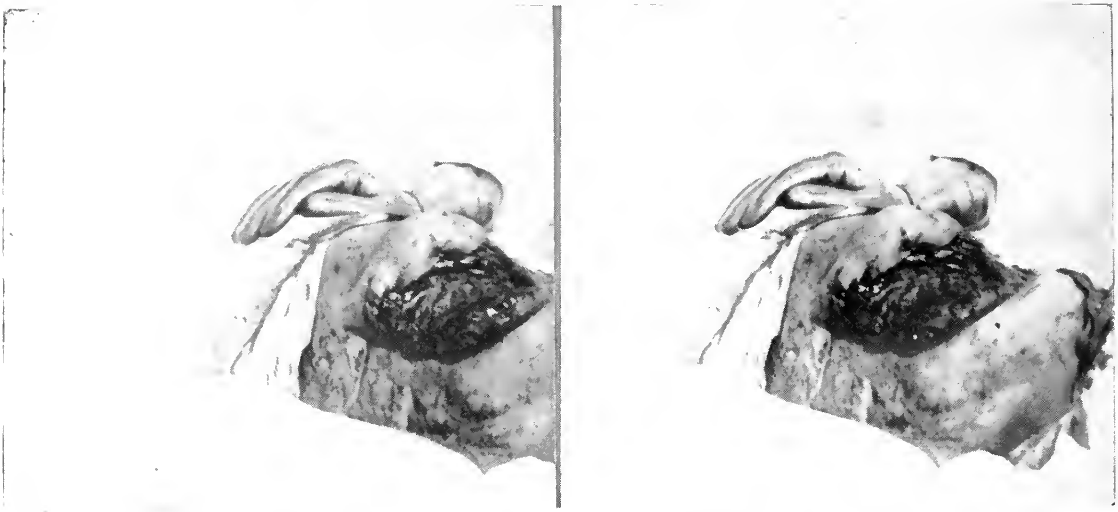


Fig. 5. Six inches of the fifth, sixth and seventh ribs was resected and silver nitrate applied to pleural surfaces, so as to secure adhesion.

and agreed that surgery was imperative. He operated on the case on October 15, 1920, first resecting about 6 inches of the fifth, sixth, and seventh ribs overlying the tumor and leaving the entire wound exposed and the skin flap rolled up for three days (Fig. 5). In order to obtain an adhesion between the pleura and the tumor, silver nitrate was applied to the entire area and surrounded with vaseline gauze. At the end of the third day, the operation was continued and a purse-string suture was placed in the tumor mass to prevent hemorrhage. On opening the growth, a mass of semi-solid consistency resembling a myeloid tumor or soft sarcoma was revealed. The entire sac was evacuated, the contents weighing about 800 gm. (Fig.6).

Pathological Examination.—Specimens of the tumor were sent to Dr. A. S. Warthin, Dr. Ludwig Hektoen and Dr. William Carpenter McCarthy. All reported a diagnosis of spindle cell sarcoma.

The tumor cavity (Fig. 7) was found

Fig. 6. Entire contents of sac was evacuated.

Fig. 7. The cavity was found to communicate with a bronchus.

to communicate with the bronchus, and the occasional opening of this probably accounted for the periodical respiratory symptoms, which were followed by a cessation of the same for long periods of time.

Three weeks after the operation, the patient was walking around the hospital and had a good appetite, having gained some 6 pounds in weight. Radium was applied to the inside of the cavity, and after regaining her normal weight the patient returned to Battle Creek, where the radium applications were continued.

The patient remained well until April 1st, when she developed an afternoon temperature of about 100° F. This was the first indisposition since the operation.

Examination showed no evidence of thoracic tumor, but an attempt at reconstruction of the resected ribs was in evidence (roentgen ray). During all this time the cavity was dressed daily and drainage encouraged.

On account of present symptoms, Dr. Case took sections of the tissue in the cavity wall for examination, on which Dr. Warthin reported no malignancy, but a pyogenic infection, from which the patient is suffering at the present time.

Interesting data on the above described case:

(1) Unique onset.

(2) Irregularity of the symptom-complex accompanied by long intervals of practically normal health. This manifestation was undoubtedly influenced by the presence of the small bronchial fistula which opened at intervals when the pressure within the tumor reached its maximum.

(3) The length of time elapsing between the initial attack and the operation (sixteen months) and the physical capability of the patient to complete the last half of her three years' course in the Nurses' Training School.

(4) The similarity of the attacks in this case and those found in many cases of pulmonary tuberculosis.

(5) The similarity of the roentgen-ray findings with those of some cystic formations.

(6) The lack of physical deficiency, such as loss of weight and strength during the sixteen months of tumor development and partial destruction.

(7) The very rapid recovery after surgical interference.

Note. Since reporting this case, Dr. Emil Beck resected the free ends of the divided ribs, thereby improving drainage, and the patient returned free of symptoms. For the past two months she has been at work (September 6, 1921).

DUNHAM'S FANS IN A ROENTGEN-RAY STUDY OF GRANITE DUST INHALATION

By D. C. JARVIS, M.D.

BARRE, VERMONT

INTRODUCTION.—If there is any one phase of lung pathology that impresses itself upon the observer in a roentgen-ray study such as the above, it is the occurrence of Dunham's fans. One cannot see them appear from day to day upon the roentgen-ray films as the examining work progresses without being compelled to admit to himself that they represent pathology. Their uniform shape and situation cause one to study them, and after observations to make deductions and draw conclusions as to their method of production, the reason for their appearance and the significance of their presence. In examining hundreds of granite cutters, one is able to select a certain part of the lung in which a fan is commonly seen, lay aside all such films, and then have the pleasure of studying the change in density of the fan area, the increase in size, and finally the progression of the lesion in this area to the point where the original fan is lost in the ever increasing size of the density, increasing in the same manner as a river overflowing its bank.

Dunham's Work.—The writer owes a great debt to Dr. Kennon Dunham of Cincinnati, Ohio, for exploring lung pathology and demonstrating its connection with the shadows seen upon the roentgen-ray film. Without his having blazed the trail, this study would have been impossible. Dunham, in 1917, in his work on stereoroentgenography, entitled "Pulmonary Tuberculosis," called attention to the fact that the roentgen ray had its limitations. He laid emphasis upon the fact that a carefully taken history and a thorough physical examination were of the utmost value. At this time he also called attention to the fact that the tree-like shadows seen upon the normal chest plate were due to blood-vessels, bronchi and connective tissue, each tree-like shadow being a composite of these three factors, but that of the three factors two were constant and one was variable. Of these three the connective tissue, which represented the variable factor, was the most important, and upon the amount present depended the density of the shadow. Attention was called to the fact that heavy trunks in themselves occurred in other diseases and did not of themselves justify a diagnosis of tuberculosis. Mention was made of the fact that a plate having a homogeneous distribution of its markings was not tuberculosis; that the most striking characteristics of the tuberculous picture are the variations of density change beyond the different group trunks, in contrast to the general homogeneous change of other diseases which might simulate tuberculosis. While all these points were emphasized by Dunham, the study of dust inhalation in the granite industry by means of the roentgen ray brings them to mind again, especially when it is possible by means of a mechanical irritant to produce films paralleling tuberculosis, bronchopneumonia and lobar pneumonia.

Lung Zones.—Dunham has divided the lung field from the sternum outward into three zones. These zones are arcs of a sphere extending from clavicle to diaphragm, and correspond to thirds of the lung field. They have been called respectively the hilum zone, mid-zone, and peripheral zone. Corresponding to these zones we notice the three sets of divisions of the bronchial tree. At the hilus we notice in the hilus zone the root divisions of the bronchial tree with trunks which are seen in the mid-zone of the lung. These trunks divide into branches, and the branches into twigs. The branches lie mostly in the mid-zone area of the lung, while the twigs lie wholly in the peripheral lung zone.

Situation of Fans in Pneumoconiosis.—One notices first of all a tendency to the formation of Dunham's fans in the branches of the first and second interspace trunks; that is, they are more commonly seen in these situations, but they occur in the whole lung field from the first interspace trunk to the base, it being possible apparently for the lung field to contain five of these fans at the same time, and as this consumes the lung field area from clavicle to base, no room existing between the fans for the formation of another, it would appear that no greater number than five is possible. These have all their bases toward the pleura and their apices toward the hilus.

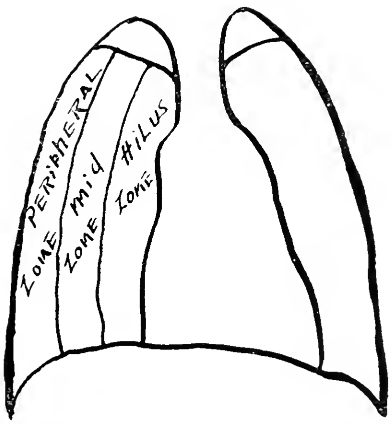


FIG. 1. Division of lung field into zones.

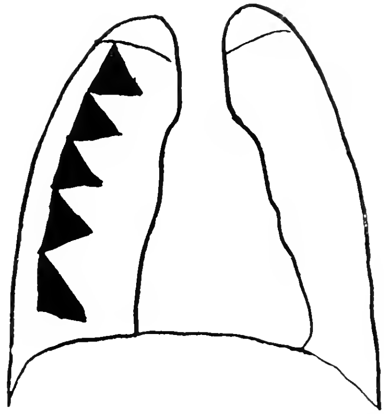


FIG. 2. Five fans, taking up all of lung, extend from above downward. Lowest fan points toward diaphragm.

The Visualization of Lymph Nodules at the Divisions of the Bronchial Tree.—In searching the lung field for a visualization of Miller's secondary lobules, we discover three sets of areas of increased densities, which one might term proximal, medial and distal, situated respectively in the hilus zone, mid-zone and peripheral zone of the lung field. These areas are not seen at one and the same time unless the reception of irritant at the lung periphery by way of the bronchi has been so great and has extended over such length of time, as to make the functioning of these areas necessary to receive irritating material passing over a blocked lymphatic system on its way back to the tracheobronchial lymph nodes. Krause, in a recent number of *The American Review of Tuberculosis,* has shown that the pathological process in a lymph nodule is dependent upon the behavior of the lesion situated peripheral to it. These areas which have been mentioned are adjacent in the hilus zone to a circular area of lessened density surrounded by a thin white line, the whole representing a lymph nodule and a branch of the bronchial tree, the bronchus appearing as if seen on end and the lymph nodule appearing like the end of a cotton wound applicator. The reason, it is felt, that this area represents a lymph nodule is because in the chest of the same cutter, by means of serial films, they are seen disappearing during a strike lasting ten weeks, only to reappear when work was resumed. If these areas always represented a calcified gland, could they fill, empty and refill all within the space of nine months? Now, using one of these proximal lymph nodules, as we shall call them, for an apex of a triangular area, we shall find the base formed by two medial nodules of the same character. In turn, using one of these medial nodules for an apex, we shall again see the base of a triangular area formed by two lymph nodules, but this time they will be those of the distal set. The sides of these triangles are formed by linear densities. From these triangular areas, which at first contain the lung markings seen in the lung as a whole, we see Dunham's fans develop. The lung pathology from granite dust inhalation being fine in its beginnings and generalized

in its distribution, its very slowness of development allows the evolution of a fan to be studied in the same individual by means of serial films.

Evolution of a Fan.—Let us then describe the evolution of a fan of the right interspace trunk. With our hilus as a starting point,we notice extending out from it an area of increased density. This area may be likened to a roadway as reproduced on the map of a city. The roadway extends to a medial lymph nodule which may be considered a junction of two other roadways coming in from the lung periphery, and from this junction these two roadways diverge in a fan-shaped manner, each roadway ending in a distal lymph nodule. We then have a triangular area similar to the Flatiron Building in New York, enclosed by lines of increased density, which we liken to the roadway around this building. Now, if we examine these lines of increased density, we shall discover on their inner side an area of increased radiability which follows closely along what we have termed a roadway. We might compare this area to the sidewalk, only it is like a sidewalk at night, because while we know it is there we cannot see it on account of the darkness. There is, however, a fine white line on the inner side of this sidewalk area which helps us in our orientation. Now, supposing this triangular area within the roadway and sidewalk was represented by a vacant lot, and people were being brought constantly to this area by a subway, what would happen? We should expect the congestion in the roadway and sidewalk to become so great that in a short time the vacant lot would be occupied by people, and if it was looked down upon from an aeroplane it would appear black compared with the surrounding country, because of abnormal activity in this particular area. A time would arrive when some desired to leave this area, and then the surface methods of transportation would be called into activity greater than that represented by normal traffic. If the lines of transportation were efficient, the triangular area would maintain its original size; if not, there would be an overflow into the surrounding territory, and when now viewed from an aeroplane the black area would have increased in size. Supposing the crowd were represented by men only, then we should have no increase in numbers other than from incoming traffic; but supposing both sexes were represented, in time the numbers would increase by means other than incoming traffic. By means of this homely illustration an endeavor has been made to describe lung pathology as seen in the making, by means of a roentgen-ray film, and the very important part Dunham's fans play in its evolution. If we analyze this illustration we shall discover that the roadways represent the arteries about which we have connective tissue formation. The sidewalks are branches of the bronchial tree; the crowd of men represents our mechanical irritant, such as granite dust, and the crowd of both sexes our bacterial irritant. The mechanical irritant entering by way of the bronchi is received at the lung periphery and leaves the lung in part by passing back toward the hilus by means of the lymphatic system, while the bacterial irritant, if of sufficient virulence, or if the lymphatic system is slow in filtering it through, proliferates in the periphery or along the lymphatic pathway and causes a lesion there.

Let us call the bacterial irritant of high virulence tuberculosis, lobar pneumonia, or whatever you wish, and the mechanical irritant pneumoconiosis, or whatever you wish. The bronchial tract we can liken to the subway and the lymphatic system to the surface cars, and the reason, it is felt, that we visualize the fan-shaped area on the roentgen-ray film is because there is lack of air in the triangular area, producing naturally an area of greater density.

Varieties of Fans.—There are apparently two varieties of Dunham's fans, the large and the small, the first being most often seen in pneumoconiosis and the second in tuberculosis. The term "fan" having been used most often in conjunction with the subject of

tuberculosis from a roentgen-ray standpoint, it doubtless has been inferred that it was a pathognomonic sign of tuberculosis; but Dr. Dunham's own interpretation of fans as given by him to me is as follows: "Fans when seen upon the *x*-ray film are characteristic of a lung lesion but not necessarily characteristic of tuberculosis. The fan of pneumoconiosis is larger and lies in the midzone of the lung field with lung pathology in the form of increased densities lying between it and the hilus. The characteristic fan of tuberculosis is small in size, lies near the pleura in the peripheral zone of the lung and is accompanied by a definite apical lesion."

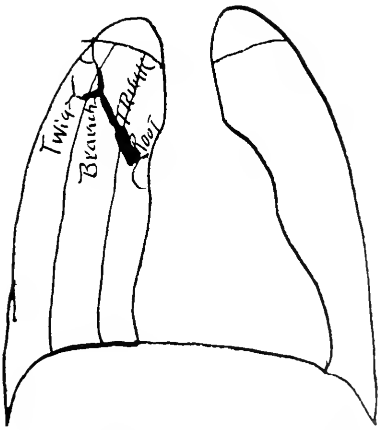


FIG. 3. Divisions of linear markings.

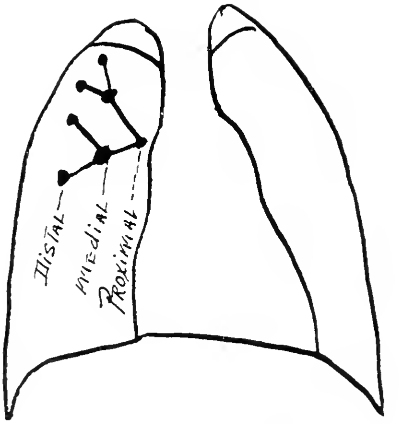


FIG. 4. Showing nodes.

Significance of Appearance.—What then do fans suggest to us when viewing the roentgen-ray film? Apparently, by means of serial films, we are able to demonstrate in granite cutters five stages of pathology witnessed on the films as follows: (1) Increase in hilus width and density, giving evidence of continued drainage of an irritant through the lymphatics from the periphery back to the tracheobronchial lymph-nodes. (2) Increased width and density of trunk markings, giving evidence of hyperplasia, from the passing of the irritant through the lymphatics. (3) The appearance of lung densities in the situation of the lymph nodules at the branching of the bronchi, these nodules taking on their function the same as the cervical glands take on theirs. (4) The appearance of fans giving evidence of an accumulation of more irritant at the periphery than the lymphatics draining that particular area can drain back to the tracheobronchial lymph-nodes. (5) The appearance of a homogeneous haze at the lung periphery pleural level, giving evidence that the work of draining the irritant back to the tracheobronchial lymph-nodes has become too great, consequently a détour is being made through the pleural lymphatics. It will be seen that fans represent one of the later stages of lung pathology when seen in a dust worker, and indicate a much-needed absence from the occupation in order that the lung may have the oportunity of clearing itself, which it makes a strenuous effort to do when given the chance. To the student in economics it indicates a much-needed system of dust-removing devices in order that the health of these dust workers be preserved and lung pathology, which produces a physiological disability, be avoided. It seems like tempting fate to interpret the causal factor of lung densities when viewing a roentgen-ray film, because by means of a mechanical irritant such as granite dust, it takes a granite cutter thirty years to produce a lung lesion which would be diagnosed if he had constitutional symptoms such as lobar pneumonia. It takes him between twenty and twenty-five years to produce a lung lesion which would be

diagnosed as bronchopneumonia if he had constitutional symptoms, and ten to fifteen years to produce a condition which would be diagnosed as tuberculosis if he had constitutional symptoms. In addition, his films may duplicate carcinomatosis and post-influenzal conditions, all without constitutional symptoms. One can imagine the difficulties awaiting the roentgenologist who endeavors to interpret the causal factor from the evidence obtained from the roentgen-ray film alone. All the granite cutters referred to were *x*-rayed, not because they were ill but because their Union voted to cooperate in the examining work to the extent that each cutter appear for examination in order that some idea might be gained as to the effect of granite dust inhalation on his lungs. They were all working and considered themselves in good health. It would then seem that the roentgenologist is justified in reporting back lung densities, but that the clinician should assume the burden of proving whether the causal factor of the lung densities is mechanical, chemical or bacterial.

SUMMARY

1. Dunham in his work on "Pulmonary Tuberculosis" emphasized the limits of the roentgen ray in chest work, but the roentgenologist is at times apt to forget these limitations.

2. In the interest of efficiency it would seem advisable to retain Dunham's terminology.

3. Dunham's fans may be seen in pneumoconiosis situated unilaterally, bilaterally, or in any part of the lung.

4. Their formation is one of blocking of the lymphatics by the irritant in question, producing hyperplasia as a result of its passing through them.

5. They represent the fourth stage of lung pathology in the making, as its progress is noted by means of the roentgen-ray film.

6. It would seem that the proving of the causal factor of these fans, whether mechanical, chemical, or bacterial, should be assumed by the clinician, the roentgenologist reporting back only densities.

REPORT OF A CASE OF OSTEOSARCOMA *

By L. B. MORRISON, M.D.

BOSTON, MASSACHUSETTS

MALIGNANCY, whether in early childhood, during the period of adolescence, or in adult life, has always stalked the medical profession like an insatiable monster, ready to devour and destroy life. Any method is sought to destroy it which does not entail too much suffering. To one constantly dealing with malignant disease comes the oft-repeated phrase from an anxious parent, husband or wife: "Can't something more be done, Doctor?" We eagerly turn to surgery, which has accomplished so much in this and other fields, but it still fails to fill the gap. In the early stages of malignancy, surgery is the method of choice, but there are the pitiful cases of a malignancy too long undiscovered or too rapid in onset and so located that the word "inoperable" is pronounced with all its menace of impending disaster, depicting the helplessness of the surgeon. By the use of the roentgen ray and radium a brighter future can be assured to many cases of this type. Many can be given weeks, months and even years of useful existence when otherwise only a life of misery shortened by death is the inevitable ending. In this day of efficiency, every patient, whether afflicted with arthritis, tuberculosis, chronic heart disease, malignancy, etc., should not only be made as free from suffering as possible but made as efficient as possible, so that he or she may, in part at least, earn a living and be made a producer. It is always worth while to do everything possible in these malignant cases, because frequently most surprising results are obtained. Any evidence of peculiarity in the behavior of a case may be the stepping stone to future successful treatment.

I wish to report the following case of osteosarcoma of the left femur in a young girl whose parents would not submit to radical surgery. The growth was rapid and emaciation extreme. The case was referred to me for roentgen therapy by Dr. Mark Rogers of Boston.

Miss G. M., aged fourteen, of previous good health and with no history of injury, during the month of November, 1918, began to have pain in the left leg and knee, severe enough to awaken her at night. She lost weight rapidly and became emaciated, weighing about 75 pounds, previous weight 116 pounds. A roentgenogram was taken at the New England Deaconess Hospital, Boston, and a diagnosis of sarcoma made. An exploratory operation was performed by the attending surgeon, December 20, 1918, to verify the roentgen-ray diagnosis. Amputation was advised, but the parents would not consider amputation. A small section was taken from the growth and the report of the pathologist follows:

Copy of Pathological Report. G. M.

Specimen from femur received December 30, 1918.

A piece of bony tissue about 1½ inches long and ¼ inch thick. Microscopic examination shows the tissue to consist essentially of a meshwork of osteoid tissue, the interstices of which are filled with connective tissue or a generally cell-rich tissue. This cell-rich tissue in places contains many vacuolated cells suggesting undifferentiated cartilage cells and osteoblasts. In a few places the osteoid tissue gives place to cartilage.

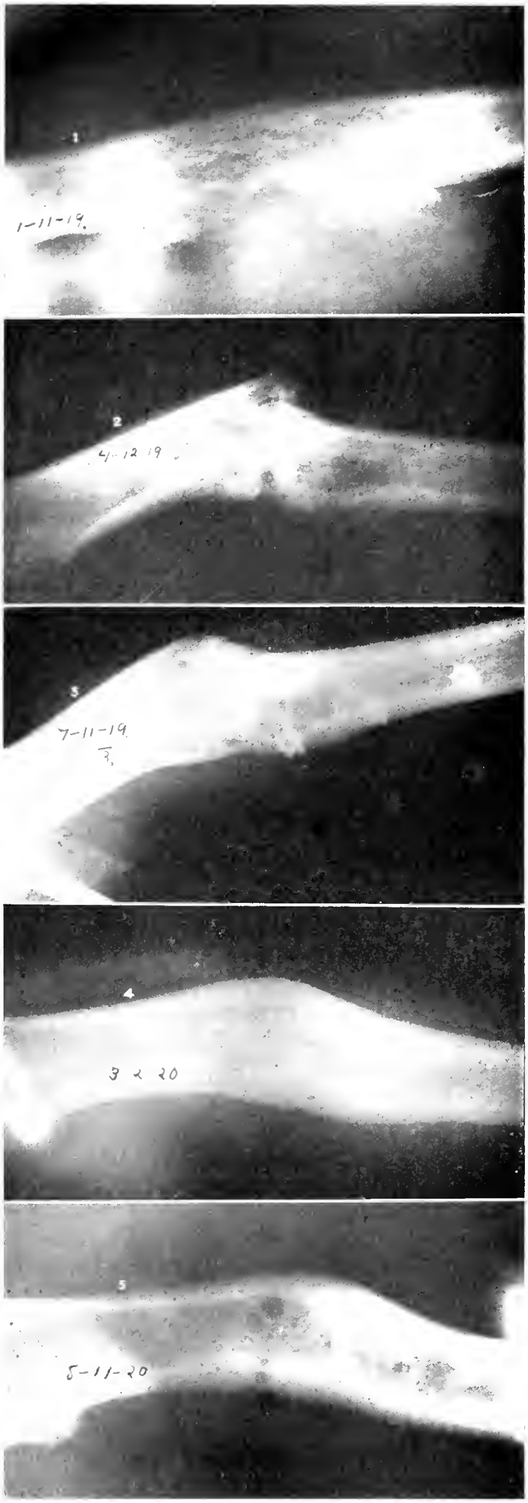
Diagnosis: Osteosarcoma.

Reference number: 18-585. (signed) J. Homer Wright.

Just how malignant this type of sarcoma is must be judged somewhat by the rapid involvement of the femur in the eight to nine weeks after onset and from the pathological report that speaks of a "*generally cell-rich tissue*." Adami[1] describes the indication of malignancy in sarcoma as follows: "The

[1] Principles of Pathology, Philadelphia, 1908, Vol. I, Chap. xx, p. 700.

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY.



FIGS. 1, 2, 3, 4 and 5 illustrate the change in the bone. The small round shadows seen in Fig. 5 are artifacts. Stereoscopic plates taken September 10, 1920, show a perfect medullary cavity and no periostitis.

tissue of origin, if it can be determined, should largely influence our diagnosis. At most, we can lay down that the more embryonic the type of cell the greater the presumptive evidence of malignancy, and that as between two tumors of the same origin the more vegetative the type of cell and the greater the departure from the adult cell standard, the greater is the malignancy."

The patient came to my office January 14, 1919. Upon examination the mass on the femur could be easily palpated. This was due to the emaciation and size of the growth. The infiltration in the soft tissues seemed to involve the upper third of the femur, below the lesser trochanter. Plate taken at this time shows an area of involvement of the left femur, starting 5 cm. below the lesser trochanter and involving 12 cm. in which the shaft, both medullary and cortical, is nearly destroyed; there was also considerable proliferation of the periosteum, particularly on the inner side. The bone was mottled and there were areas of rarefaction and areas of density showing new bone formation. Treatment was instituted, cross-firing through as many portals of entry as possible, using an 8½ inch spark gap with 3 mm. of aluminum for filters and using a 10 inch anode distance. The pubic and inguinal regions were also cross-fired. A full dose was given over each area. Soon after this treatment there was a pathological fracture at the site of the growth and the leg was placed in a Thomas splint. The patient was unable to be brought in for treatment until April 12, 1919, when treatment was repeated. The patient was next seen and treated July 11, 1919; at this time there had been a metastasis in the left frontal and right occipital regions of the skull, large, hard masses about 2½ to 3 cm. in diameter. The local physician had incised the frontal area and bloody exudate was found. Treatment was instituted over the skull sufficient to cause epilation. At this observation there was a slight dermatitis over the thigh with marked brown pigmentation. Plates were taken and treatments continued at intervals until June 1, 1920, showing gradations of healing, until at the present time

Fig. 6. Fig. 7.

Fig. 6. Taken July 11, 1919; shows an irregular area of bone destruction in the left frontal from a metastatic growth; the area in the occiput does not show, it is seen only in the anteroposterior view.

Fig. 7. Taken December 1, 1919; shows the healing process well started and shows the margin of the occipital area.

there is no evidence of malignancy seen in the femur. All induration has left about the areas in the skull and the area in the left frontal seems healed. As yet the regenerated bone is not quite as dense as the surrounding bone. The area in the occiput is about two-thirds healed. A careful examination of the skull, chest, abdomen and extremities made August 19, 1920, fails to reveal any evidence of a recurrence otherwise than noted. The patient is well, and is having no symptoms of a pathological process at the present time.

It is interesting to note that the lesion in the thigh was operated on and a small portion removed for examination, though no attempt to eradicate the disease was made, and later there was a traumatic fracture. The lesion in the left frontal was incised and drained, while the lesion in the occiput had no surgical interference, and with the same dosage applied here as over the frontal, healing is slower. Whether this is just a coincidence, or whether there is definite value in enough surgical interference to set up an acute, inflammatory process before giving

Fig. 8. Fig. 9.

Fig. 8. Taken March 2, 1920; shows the frontal area nearly healed and the area in the occiput.

Fig. 9. Taken May 23, 1920; shows the frontal area nearly healed except in the central portion, and brings out the larger area of the occipital growth.

FIG. 10.

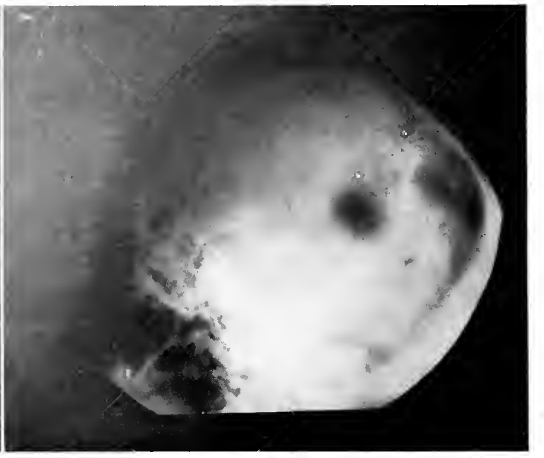


FIG. 11.

FIGS. 10 and 11, taken August 19, 1920, show the frontal area practically healed and the slower healing margins of the occipital growth.

FIG. 11. Taken August 19, 1920; shows the healing margins of the occipital growth.

treatment, I am unable to state. This one case suggests it.

In my review of the literature, although it has not been exhaustive, I have been unable to discover similar cases. I report this case to illustrate the value of roentgen therapy in these seemingly extreme cases, and also to indicate the possible value of sufficient surgical interference in sarcoma to set up an acute inflammatory process before treatment is instituted, realizing that the surgical rule is high amputation and non-interference with the growth for fear of transplantation or metastasis.

EXTRA BONES IN THE WRIST AND ANKLE FOUND BY ROENTGEN RAYS

By A. HOWARD PIRIE, M.D.
MONTREAL, CANADA

THERE are certain extra bones in the wrist and ankle which appear fairly frequently in roentgenograms and should be familiar to surgeons and roentgenologists. There are others that are moderately rare and still others that are very rare.

The object of this paper is to state my experience as a roentgenologist regarding these extra bones.

There are no extra bones in the hand that can be said to appear often in roentgenograms, but in the foot there are a few fairly common, viz., the os trigonum, the tibiale externum, secondary os calcis, os peroneum, and another extra bone without a name.

In the hand there are two extra bones which may be considered moderately rare, viz., the os centrale and the os triangulare. All the other extra bones are very rare.

Roentgenologists examine many more wrists and ankles than anatomists do, and it is not surprising that extra bones considered rare by anatomists should be found fairly often by roentgen rays.

Knowing and recognizing these extra bones become important when the question of fracture arises and an extra bone is found to be present. It has an even greater medico-legal interest when an extra bone is found in a case of suspected fracture. I have seen such a bone and a fracture lying side by side and have been able to prove that the extra bone was not part of the fracture by examining the other wrist and finding the extra bone present in it also.

One is asked what these extra bones represent. A few of them are explained by comparative anatomy; for instance, the os centrale in the wrist is a constant bone in lower animals right up to the monkey. Another more general explanation is that in the embryo there are many more centers found for bones than are found in the adult, and that during development these fuse together to form the normal number of bones in the wrist and ankle, but occasionally one center persists and ossifies, forming an extra bone. I lately examined a fossil of a saurian in which the wrist was represented by many more than the usual number of bones. The extra bones found in the wrist of man may be the analogues of these.

Extra bones which are found separate at times are found in other cases united to other bones. An example of this is seen when the styloid of the ulna is unusually long. This extra length is caused by the fusion of an extra bone, the os triangulare, to the tip of the styloid.

Sesamoid bones are in the same class as the extra bones and great variation is found in the sesamoid bones of the hand and foot. Sesamoid bones are much more common in the fetus than in the adult. Most sesamoids have no function and are found where they are in order to get rid of them.

About twenty extra bones have been described in the wrist. The full list can be found in the last edition of Quain's "Anatomy." I shall confine myself to those of which I have had personal experience, viz., in the wrist: (1) os centrale; (2) os triangulare; (3) ulnare externum; (4) radiale externum; (5) os vesalianum, and (6) divided scaphoid.

Taking first the os centrale (Fig. 1). A variation of this shows the os magnum with a projection on it which represents the os centrale fused to the os magnum. In other cases one sees a space between the os magnum and the distal part of the scaphoid, at one time probably occupied by the os centrale, which has disappeared and its place been taken by fibrous tissue. The os centrale is found constant in monkeys as one of the bones of the wrist.

The os triangulare is found in 65 per cent of second month embryos, but it is moder-

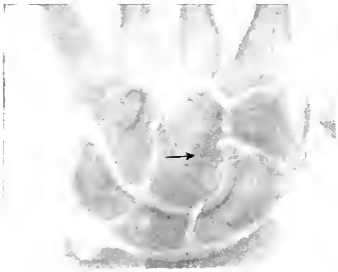


Fig. 1. Os centrale.

Fig. 2. Os triangulare.

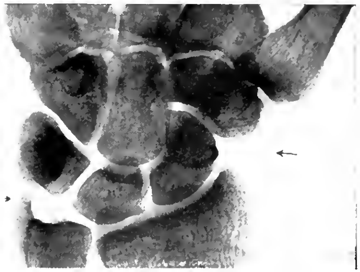


Fig. 3. Long styloid due to fusion of os triangulare.

Fig. 4. Fractured styloid and os triangulare.

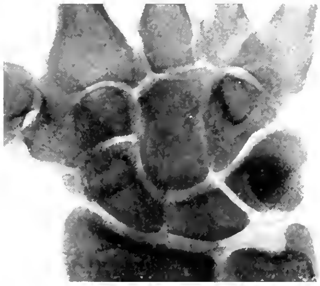


Fig. 5. Radiale externum.

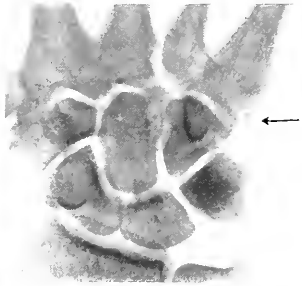


Fig. 6. Os vesalianum.

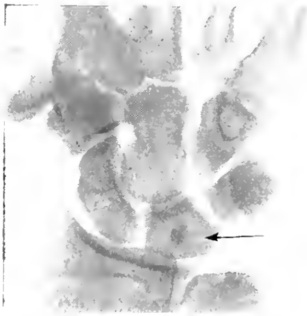


Fig. 7. Thickening in semilunar.

Fig. 8. Os trigonum.

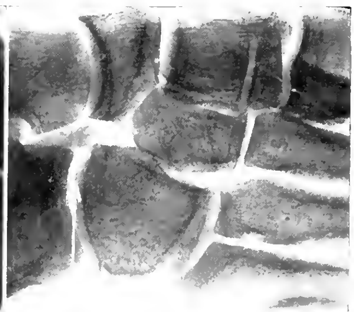


Fig. 9. Secondary os calcis.

ately rare in the adult (Fig.2). It is a perfectly formed little bone like a sesamoid. It must not be confused with a fractured styloid. In the latter the rough edge of the fracture is evident. In old cases of fracture the rough edge disappears, but the styloid remains deformed.

Examination of both wrists should be made when the presence of an extra bone is suspected, and if it is present on one side it will usually be found on the other side. Figure 3 shows an extra long styloid process. This appearance is caused by the fusion of the os triangulare with the styloid process. Fracture of the styloid process is very common, but a true os triangulare is moderately rare. Comparison of right and left wrists easily settles the question when one wrist only has been injured. Figure 4 shows a fractured styloid and an os triangulare.

The ulnare externum is a very rare bone in my experience. I have seen it only once. Figure 4 shows the only case I have seen. It lies between the fifth metacarpal, the unciform and the cuneiform.

The radiale externum is the end of the tubercle of the scaphoid. It is very generally found among mammals, but it is very rare in man. Figure 5 shows this bone present in the left hand. It was not present in the right hand, but in the right scaphoid the tubercle was larger than in the left, and this prom-

inence represented the fused radiale externum.

The os vesalianum is called after Vesalius, who described it as a normal sesamoid bone of the wrist. While examining a treatise on anatomy by Vesalius I found a diagram of this bone. I had thought that in studying these extra bones I was pursuing rather a new subject, but as Vesalius described this bone nearly three hundred years ago, I was forced to the conclusion that the subject was decidedly old and only neglected. Figure 6 shows the only specimen that I have found.

The divided scaphoid is frequently found in two parts. It may be in two parts at birth. The appearance of the scaphoid in roentgenograms is more varied than that of any other bone of the wrist. I have found many cases of it in two parts, but in all there was evidence of fracture. Comparison with the other side should be made when a divided scaphoid is suggested, and if it exists also in the other wrist without history of accident the diagnosis of divided scaphoid is justified.

These are all the extra bones in the wrist that I have found. At one time I thought I had found several others, but when examined stereoscopically it was found that what appeared to be an extra bone was really only a thickening inside a normal bone. Figure 7 shows an example of such a thickening in the semilunar. These thickenings may be the evidence of old healed tubercular disease and correspond to the small calcified spots so often seen in the lungs. I have found them in the scaphoid, pyramidal, and semilunar bones. They may be multiple.

In the foot the extra bones which I have found are as follows: (1) os trigonum; (2) secondary os calcis; (3) tibiale externum; (4) os peroneum; (5) os vesalianum, and (6) an ossicle with no name.

The os trigonum is said by Pfitzner to occur in 7 to 8 per cent of ankles. In roentgenograms it is quite as common as that. It is a constant bone in marsupials with five

Fig. 10. Tibiale externum.

Fig. 11. Os vesalianum.

toes. It is really the posterior external tubercle of the astragalus. It is by far the most frequently seen extra bone of the ankle. Figure 8 shows the os trigonum. It may be short and stout or long and slender.

The secondary os calcis is a small bone which is occasionally found in the angle between the os calcis, the astragalus and the scaphoid. Figure 9 shows a specimen of this bone. It corresponds to the os centrale in the hand.

The tibiale externum is found at the tuberosity of the scaphoid. It is a constant bone in many animals and is found in the second-month human embryo. Figure 10 shows a specimen of it. It is important for surgeons to be familiar with this bone as it looks like a fracture. It more frequently than not occurs on both sides. It is commoner in women than in men.

The os peroneum is a common bone. It lies in the tendon of the peroneus longus. I have seen it single, double, triple, quadruple, and multiple. Its position varies, but usually it is seen in a semilateral view lying between the os calcis and the scaphoid. It is present in Figure 8.

The os vesalianum is a very rare bone which occurs at the base of the fifth metacarpal and has to be distinguished from a fracture. This is best done by comparison with the bone of the other side. Figure 11 shows an os vesalianum. It is seen best in an anteroposterior view.

The last bone I have to mention is an ossicle with no name. I first noticed it five years ago and have been watching for it since. I now have 14 cases of it. I have found it in both feet in 4 cases. These are the only cases I have examined on both sides especially for this bone. After finding a few cases, I consulted the professor of anatomy in Edinburgh University and his answer was very interesting. He had never seen it, he had never heard of it, and after looking up the literature on accessory bones he could find no mention of it, but he was prepared to admit that it existed, as he had found its articular surface on the scaphoid in some cases. He promised to look out for it in the dissecting room and after a year he wrote to me and told me that he had found one . It therefore seems evident from these 14 cases which I have collected that this extra bone is not infrequently present at the posterior and upper part of the navicular as shown in Figure 12. I have one case in which it appears to be fused to the scaphoid and one in which it appears to be fused to the astragalus. Figure 13 shows the largest example of this bone I have found. It was present in the right and left foot and there

Fig. 12. Extra bone.

Fig. 13. Extra bone.

was no history of injury to account for its presence.

These are all the extra bones of which I have had personal experience except a few single specimens which I cannot name or speak further about until I find enough other specimens to place them in a category by themselves.

In order to find these few extra bones that I have mentioned I have examined an immense number of roentgenograms. I had special opportunity of doing this, as during the war I had to inspect all the roentgen-ray departments of the C. E. F. in England every three months and once those in France. During these visits the monotony of looking at fractures and foreign bodies was relieved by looking for extra bones, and after finding a few I kept on looking until now I have a representative collection of what an average roentgenologist may be expected to find.

RÉSUMÉ

About half a dozen extra bones occur occasionally in normal ankles and wrists. These have to be known and distinguished from fractures. This is best done by comparing the joint of the other side.

PRIMARY SARCOMA OF THE VERTEBRAE*

WITH REPORT OF FOUR CASES

BY KARL F. KESMODEL, M.D.

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WASHINGTON, D. C.

PRIMARY tumors of the spine and cord are not rare, but primary sarcoma of the vertebrae is uncommon. Few cases were found in the literature. In an article by Roberts[1] he quotes Coley as finding only 12 cases of sarcoma in this region in a series of 12,000 cases.

The detection of this lesion is difficult, often missed, and often misinterpreted as tuberculosis of the spine. The presence of tuberculosis in the family of the patient is usually considered against neoplasm, but as shown by 2 of the cases reported, it should not legislate against the diagnosis of sarcoma, and, as Roberts states, sarcoma may appear in tuberculous subjects.

Age often plays an important part in diagnosis, as certain lesions most often occur in "age periods." But in sarcoma of the spine, age cannot be given undue consideration. It may occur from one year to seventy. Ewing[2] states that of thirty-one extra-dural spinal sarcomata one occurred between the ages of one and nine; three between ten and nineteen, none between twenty and twenty-nine; seven between thirty and thirty-nine; ten between forty and forty-nine; nine between fifty and fifty-nine; and one between sixty and sixty-nine. (This includes 81 cases tabulated by Schlesinger in 1898, many of the cases collected by Collins, and some recent reports up to 1915.) Of the cases reported by Roberts one occurred between the ages of one and nine; two between ten and nineteen; and one between fifty and fifty-nine. Of the cases reported here from the records of the Massachusetts General Hospital, one was between ten and nineteen years of age, one between forty and forty-nine, and two between fifty and fifty-nine.

A history of trauma frequently precedes the presence of the tumor. At times no history of trauma is obtained. In the cases of spinal tumors reported by Traube, Forster, Ollivier, Hunt and Woolsey[2] it is

*Published with permission of the Surgeon General, U. S. Army, who is not responsible for any opinion expressed or conclusions reached herein.

reported. In the cases reported here it will be noted in two, but in one it antedated the appearance of the neoplasm several years and may be discarded. Apparently trauma may be a direct exciting factor: it may hasten the rapidity of growth of a neoplasm already present, or it may have no association with it whatever.

Pain is a prominent symptom. It presents itself early and is severe. It may be local or referred along the course of the nerve emerging at the site of the tumor. It is usually unrelieved by immobilization. Considerable tenderness may be elicited at the site of the lesion.

Evidence of pressure at the roots of the peripheral nerves appears early in the disease. As previously stated, pain is a prominent symptom. Various sensory disturbances, such as anesthesia and paresthesia are noted. The sensation of touch and thermal changes may be absent in certain areas. Often there is a difference between the reflexes of the two sides, or they may be undisturbed or entirely absent on both sides. Oppenheim, clonus and Romberg may be obtained. There is muscular weakness with ataxia and atrophy.

Positive roentgenographic findings may be entirely absent. There may be no observable change in the outline or structure of the vertebrae to account for the symptoms and physical findings. When they are present, they are by no means characteristic. They are easily confused with tuberculosis, and it may be only by repeated examinations at frequent intervals showing the rapid destruction with the involvement of adjacent vertebrae, that a diagnosis may be derived. When changes in the vertebrae are observed, it is seen that although an adjacent one may be involved, the intervertebral space is lessened but little. In the cases seen at the Massachusetts General Hospital, it was noticed that the margins of the body were first attacked, adjacent vertebrae being involved, without the complete destruction of any. The destruction is irregular and the familiar "wedge-shaped" body is often missing. As a result, there is but little deformity in the vertical axis of the spinal column and the kyphosis ordinarily seen with the amount of destruction present is not observed. Abscess formation is absent, but invasion of the surrounding soft tissues by the new growth may simulate an abscess with calcification.

Sarcoma of the vertebrae must be differentiated from tuberculosis of the spine, spinal cord tumors, metastatic malignancy, fractures, syphilis and typhoid. Tuberculosis of the spine involves the joint early, destroying the intervertebral disc, whereas sarcoma first attacks the body. As a result, in the former condition the intervertebral space is lessened and eventually obliterated. In sarcoma the intervertebral space is affected but little. In neoplasms, adjacent vertebrae are soon involved without the complete destruction of any, but in Pott's disease the process is more localized and in the individual vertebra is more extensive. Kyphosis appears early in tuberculosis, but in neoplasm it appears late, after several vertebrae are involved, if at all. In the latter condition there is an invasion of the soft tissues which is not seen in the former, and the abscess so common in tuberculosis is absent in sarcoma.

The differentiation from primary tumors in the cord rests almost entirely on the radiographic findings. The clinical findings of the two are too closely allied for differentiation. If the tumor is primary in the cord, the changes seen in the vertebrae are due to pressure, not destruction, as seen in the true vertebral tumors. If the cord tumor is of the slow-growing type, a fusiform widening of the neural canal may be seen, or if of the more rapidly growing type, a distinct widening in a specific region with some erosion of the inner margins where the tumor passes out of the canal. In sarcoma of the vertebrae the outer margins of the body seem to be the first portion attacked, and, as previously stated, the lesion is primarily of the destructive type.

In metastatic malignancy of the spine, the lesion is always multiple when discovered and the primary lesion can usually be demonstrated. The location of the metastasis in

the individual vertebra is central, whereas the primary tumor usually appears at the margin.

In fractures of the vertebrae there is usually a history of a severe trauma, the deformity is of the compression type and there is no evidence of bone destruction. The fragmentation observed in some fractures of this region is not seen in neoplasms. However, should a fracture occur at the site of the tumor, the true lesion may be entirely missed.

Syphilis and typhoid of the spine can usually be ruled out by history and laboratory tests. The roentgenographic plate in these two conditions differs from that of the primary tumor in that the process is often accompanied by proliferative changes, bridging or actual ankylosis, and other evidence of repair which is absent in neoplasm.

The following 4 case histories are taken from the records of the Massachusetts General Hospital. All were proven at operation. I am indebted to Dr. M. S. Bringman, radiologist at the Massachusetts Homeopathic Hospital, for the privilege of reproducing the first roentgenogram of Case I, and to the Pathology Department of the Harvard Medical School for the privilege of roentgenographing an old specimen.

Case I (Hospital No. E.S. 249667). N. R. J. Female. Age, fifty-nine. Admitted January 9. 1921.

Family History.—One sister died of tuberculosis six years ago. The patient nursed this sister during her illness.

Past History.—Twenty years ago she fell down the stairs, injuring her spine. She had a spinal curvature afterward. About three years ago, just before her present illness, she became subject to frequency in urination.

Present Illness.—First symptom noticed was that she dragged her feet; then numbness appeared. This occurred about three years ago. The numbness ascended, reaching the level of the waist line, and she could not walk without falling over. She entered a hospital, and after being examined, including *x*-rays, she was told that "bones were pressing against the spinal cord." She was put in a plaster shell for six weeks, when the paralysis disappeared and she was able to walk. She was kept in the shell four weeks longer, then a corset was substituted. Shortly after the change her legs began to draw up and she could not straighten them out. The plaster jacket was again applied and in addition traction, this treatment continuing for three months. The plaster was then replaced by a leather jacket. Eighteen months ago she became suddenly paralyzed in both lower extremities, sensation being lost up to the waist. For the first time she had incontinence of urine and feces. Since then the paralysis has advanced upward about 4 inches. She has suffered almost constantly with girdle pains for the last year.

Physical Examination.—There is a moderate kyphosis from the 7th to the 10th dorsal vertebra and a marked lumbar lardosis. Spastic paralysis in both lower extremities. Superficial abdominal reflexes absent. Knee-jerks barely present, no clonus or Babinski. All sensation to touch, pain and thermal changes is absent to the level of the 6th dorsal. There is an area of hypersensitiveness just above this. Incontinence of urine and feces.

Roentgen-ray examinations were made on January 11th and February 3rd and 5th. Examination of the roentgenograms of the lower dorsal region shows a definite lesion which is characterized by destruction of the intervertebral disc and erosion of the bodies of the vertebrae. Just below and to the right of the spinous process of the 11th there is a dense shadow in which there is evidence of calcification. Probable diagnosis, tuberculosis, but sarcoma considered (Figs. 1 and 2).

Laminectomy done on February 5th. Pathological report: Chondrosarcoma.

Case II (Hospital No. W.S. 211282.) C. C. Female. Age, fifty-five. Admitted October 24, 1916.

Present Illness.—About fourteen months ago, while gardening, patient suddenly experienced extreme pain in her left leg. Eleven months later, the right leg became similarly affected. Treatment previous to entrance had been morphine for the relief of the intense pain which is persistent.

Physical Examination.—The patient appears to be in great pain, the history being obtained

Fig. 1.

Fig. 2.

Fig. 1. Case 1. Lateral view of the lower dorsal spine. Note the similarity to tuberculosis of the spine, but erosion of the anterior surfaces of the two bodies designated by the arrows suggests the true nature of the lesion. (From the Massachusetts Homeopathic Hospital Records.)

Fig. 2. Case 1. Note the extensive destruction on the anterior margins of the designated vertebrae, with only slight narrowing of the intervertebral space.

between groans. The legs and hips are complained of most severely. Knee-jerks active and equal. No Babinski. Doubtful clonus on the left. No discoverable change to touch, differentiation between sharp and dull, and temperature stimuli, except on the lower leg where all seem somewhat diminished, but without definite limitation. Tenderness over the third and fourth lumbar vertebrae.

Roentgen examinations were made on October 25th and 26th, and November 2nd and 7th. The plates reveal a distinct deformity of the 5th lumbar vertebra, destruction on the left side with thickening about the joint surfaces, and some irregularity in outline. The fourth lumbar also shows evidence of involvement.

On November 9th a sensory examination revealed a definite clonus, well sustained on the left. Suggestion of Babinski on the right. Muscles of both legs show general weakness. A firm mass was struck in the region of the fourth lumbar when a spinal puncture was attempted.

Laminectomy revealed a roughening of the bodies of the 3rd, 4th and 5th lumbar vertebrae and apparent erosion. Pathological report: Small round cell sarcoma.

Case III (Hospital No. W.S. 188959.) C. J. DeF. Male. Age, forty-three. Admitted May 5, 1913.

Present Illness.—About one year ago patient's back felt as though he had strained it. His local doctor diagnosed the condition lumbago and strapped his back. A few months later he developed pain in the left leg which became worse on exertion and caused him to limp. About four weeks ago the left leg became numb and pained him to such a degree that he could not use it and remained in bed. For the past two weeks, rest in bed has failed to relieve the pain.

Physical Examination.—Slight atrophy and some weakness of the left leg. Back is very stiff with a low lumbar scoliosis. Motion and pressure painful. No knee-jerk on left, though present on the right. Romberg backward.

The roentgen-ray examination was negative except for "slight hypertrophic changes."

Laminectomy revealed a new growth in-

volving the second and third lumbar vertebrae. Pathological report: Fibrosarcoma with giant cells.

Case IV (Hospital No. Orth. W. S. 183172.) A. J. McI. Male. Age, sixteen. Admitted June 26th, 1912.

Family History.—Mother died of phthisis.

Present Illness.—On March 14th, patient fell, injuring the lower dorsal and upper lumbar spine. Was not unconscious, rode home. Since then the pain over this area has gradually increased. Since May 16th has been treated (strapping) in the Out-Patient Department without relief. During the past two weeks a large area over the external and anterior surface of the right thigh has become anesthetic. His gait has changed. Has frequent headaches.

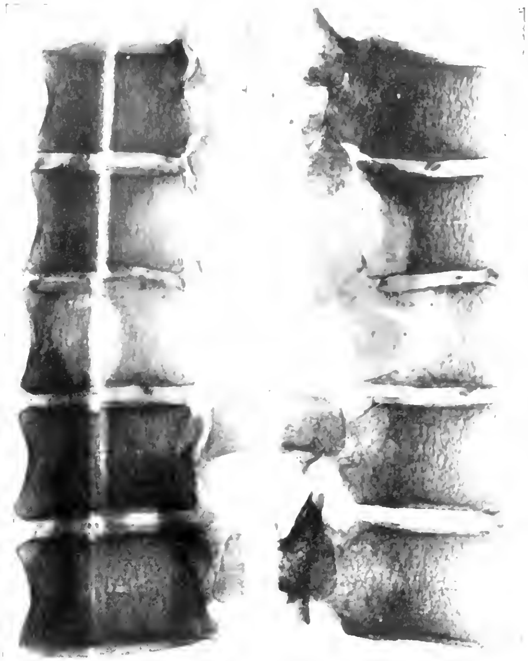
Physical Examination.—Walks with some instability, complaining of weakness in the right knee. There is a slight depression over the 10th dorsal vertebra. In the posterior subcostal region on the right, there is an area of swelling the size of the hand, which is very tender on pressure. Straight leg raising to about one third, beyond that pain in the region of the 4th lumbar to the right of the spine. Clonus and Oppenheim present. Area of analgesia present over the external aspect of the right thigh just below the trochanter.

Operation revealed a tumor which consisted of encapsulated liquid containing broken-down tissue which was reported by the pathologist to be "giant-cell sarcoma."

The roentgen-ray examination was post-operative, and showed continued evidence of the disease.

CONCLUSIONS

Primary sarcoma of the vertebae is not a common lesion. It may or may not give roentgenographic evidence of its presence, and when it does the findings are easily confused with Pott's disease. Repeated examinations showing the rapid destruction of bone, with but little involvement of the intervertebral discs, are necessary to determine the true character of the lesion. With the advent of



Figs. 3 and 4. Roentgenograms from a specimen from the Warren Museum, Harvard Medical School. "A portion of the dorsal region showing a new growth which had started in the body of one of the vertebrae and appeared on the outside along the spinous process." (From the records of the Museum.) Although three bodies are involved, no one is completely destroyed. Intervertebral spaces are only slightly lessened and the process seems to have attacked the posterior portions of the bodies.

the Potter-Bucky diaphragm, spinal pathology being much better observed, the determination of lesions therein may be more accurately made.

In conclusion, I wish to thank Dr. George W. Holmes, whose kind assistance has made this paper possible.

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MY STUDIES ON THE PHYSICIAL FOUNDATIONS OF DEEP THERAPY TREATMENT*

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PART I

STUDY OF THE PHYSICAL CONDITIONS

MR. PRESIDENT, Members of The American Roentgen Ray Society, Ladies and Gentlemen: Your President invited me to make a report on my work in deep therapy, and I have undertaken with pleasure the long trip to make the report and to learn a great many new things in your beautiful country; for in the exchange of knowledge lies the progress of science. There should be no barrier to things which are of benefit to all humanity.

I wish to present in two short papers the results of my studies. The first paper deals with the physical laws of irradiation and the exact knowledge of the distribution of the rays within the tissues. The biologist can only draw conclusions from the reaction on tissue when the above-mentioned conditions are accurately ascertained.

The second line of study, which was far more difficult than the first, covers the technical requirements for a practical solution of the problem. This problem has in part been solved in your country. I have been working in Germany on the development of the apparatus and have spent many years of thought on producing one that would generate very high voltages and would operate continuously without change under conditions of absolute safety and within small dimensions; that is, an apparatus which could be used by the medical man without danger and without great expense for operation and upkeep. In the meantime my friend and co-worker, Dr. W. D. Coolidge, has still further developed his wonderful tube, with which I could obtain the most accurate results and with which I could bring to their best effect the high voltages. This subject will be covered in my second paper.

Before arriving at my last results, I shall briefly touch upon the history of how the problem started. In 1904, nearly seventeen years ago, I first formulated the problems. At that time superficial skin diseases were being treated with roentgen rays. A few men, among them Americans—Senn, for instance—had made experiments to ascertain whether diseased areas which were not situated at the surface could be influenced by the rays. The results were not satisfactory, and Professor Perthes, a German surgeon who was studying these matters at the same time, published interesting experiments, coming to the conclusion that an insufficient quantity of rays penetrate to a depth. I naturally approached the problem from the physicist's point of view and found at that time the following situation: At the surface a cure by rays could be noted, the physical conditions were therefore right for a good result at the surface. I therefore concluded that it only would be possible to determine whether a disease in deep tissues could be cured, if we could produce in them just as favorable physical conditions of the rays as when they were applied to the surface. I asked myself: What are the physical conditions at the surface, and is it possible to produce these same physical conditions at a depth?

In two simple diagrams I shall show the foundation of the problem. You know that in whichever way roentgen rays are produced—with high tension direct current,

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alternating current, induction coil or transformer, it is never possible to produce *one kind* of rays only, but always a *mixture* of different rays.

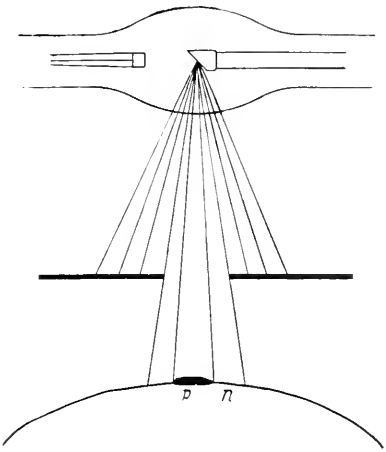

Fig. 1.

In the first picture a lesion is shown on the surface of the body. When it is rayed from a focus placed at a certain distance, just as it was done seventeen years ago, and

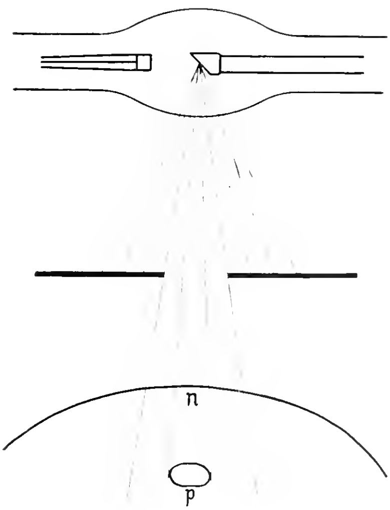

Fig. 2.

the rays strike the skin and the proper dose given, it may happen that the disease is cured without the skin being damaged. The biologist will say the reason is that the cells of the diseased part are more sensitive than those of the healthy part; and if that is the case the physical part is very easy, because healthy and diseased cells when rayed from the same tube receive the same quality and quantity of rays. The physical conditions are the same on all points of the surface, i.e., we have a homogeneous field.

Regarding the second figure, in which the diseased part is a few centimeters below the surface, the physical conditions are very different—*qualitatively* different, because the depth receives a different composition of rays compared with the composition on the surface, owing to the absorption of the long wave-length rays in the beginning of their path; *quantitatively* different, because we have fewer rays at the depth than on the surface on account of the greater distance and the loss by absorption. The physical conditions in the depth are therefore not the same and the biologist cannot compare the reaction on the surface with the effect in the depth. From these considerations I developed the physical laws of deep therapy, which are known in Europe as the *Laws of Homogeneous Irradiation.* They were the foundation for the development of deep therapy, and have to-day proven to be true in all points. To-day it is very simple and natural, but it was not so seventeen years ago, when the nature of roentgen rays was unknown and their laws could not have been known. Amongst those who had grasped at the first the importance of the physical laws of deep therapy and had made use of them consciously I should like to mention Beclère of Paris and Wetterer of Mannheim.

The laws of homogeneous irradiation are in abbreviated form the following:

First Law. The foundation of roentgenotherapy is formed by the biological experience that different cell forms show different sensitiveness to the same roentgen rays.

Second Law. Rays of different penetration are to be regarded as different medicaments, so long as the contrary is not proven. The difference in sensitiveness of different cells appears more marked if hard rays are applied.

Third Law. In order to determine and utilize precise differences in sensibility, the

homogeneity of the field of radiation is a required condition.

Fourth Law. The non-homogeneity of a treated field detracts from the effect. The conditions for a favorable influence upon the disease are not fulfilled when the non-homogeneity of the field is greater than the difference in sensitiveness between the diseased cells and the healthy.

This law, the law of the *limit of effect,* can easily be expressed by algebraic formulae.

If we had a quantitatively homogeneous radiation and a diseased cell which is a times as sensitive as the normal cell, then a favorable effect can take place when the intensity I_n on the normal cell is not more than a times as large as the intensity I_p on the pathological cell given the same time of radiation. In a certain time t the reaction is equal to the product of intensity times sensibility. At the moment when the product on the normal cell becomes larger than on the diseased cell we have reached the *limit of effect.* We can formulate:

$$I_p \times a \times t \geqq I_n \times t.$$

Fifth Law. There is a homogeneity of space or quantitative homogeneity and a specific homogeneity, or qualitative homogeneity. The aim must be to dose the diseased cells of the entire diseased zone throughout its extent with the needed quantity or dose of irradiation, and to have this dose of the same quality throughout.

Sixth Law. The condition of qualitative or specific homogeneity is fulfilled when the irradiation in the complete zone during its course through the body does not change its composition or consistency. The reaction on the different cells is then physically only dependent on the *intensity and the time.*

Seventh Law. The intensity of effect may not differ more than the degree of sensitiveness. This is only a more precise statement of the fourth law, the *limit of effect,* but one may try to increase the intensity on the diseased zone in the depth and to raise it above the intensity on the surface, and in the vicinity of diseased cells.

For seventeen years, unceasingly, I have tried to fulfil the above-mentioned conditions in the deeper tissues of the body, and to work out for the medical man some simple method by which he may know the physical effect of irradiation in any part of the body, both qualitatively and quantitatively. It was and is possible to improve the conditions with the old methods—by using penetrating qualities of the radiation, better machines and tubes, by raying from great distances, from different angles, so as to make the rays cross within the body (the cross-fire method), and by the use of exactly determined filters; but perfect results are only obtained when using extremely high voltages and making use of the diffused radiation within the body or in media physically similar to its tissue. My last work, a part of which Dr. Coolidge saw on his visit last year, consists of measurements made during many years and shows the following results:

Having *a well-known composition of rays* (Part II will explain how they were produced) *we have measured the distribution of the intensity of irradiation within a body* (Figs. 3, 4, 5 and 6). These measurements have been made with four kinds of rays—the most penetrating which up to then could have been produced continuously. Five focal distances were studied each for three different-sized treatment fields—small, medium and large. These measurements were undertaken after Friedrich in Freiburg had shown on careful study, that the rays are absorbed in water practically at the same rate as in tissue. It took

Table.

The Dose in the Depth in procent of the Dose on the Skin for a rectangular Cone of 36° and 35° opening and 30 cm focal distance.
Total Intensity incl. additional Int. from Diffusion.

Depth below surface cm	Narrow cone 13⅓% reduction of Intensity for a cm Water	Cone of 50° and 35° opening 13⅓% reduction of Int. for a cm of W.	Narrow cone 11⅓% reduction of Int. for a cm. of water	Cone of 56° and 35° opening 11⅓% reduction of Int.
0	100	100	100	100
1	63·9	88	82·8	90
2	65·6	75	69·7	78
3	53·3	64	57·1	66
4	43·4	54	47·6	57
5	35·4	47	39·7	51
6	28·2	42	33·2	49
7	33·7	38	27·8	44
8	19·4	36	23·3	42
9	15·9	34	19·6	40
10	13·1	33	16·4	39
11	10·7	30	13·8	34
12	0·8	24	11·7	28
13	7·3	18	9·8	22
14	0·0	13	8·3	16
15	5·0	10	7·0	11

FIG. 3.

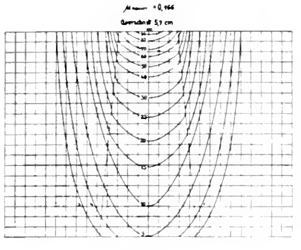
FIG. 4.

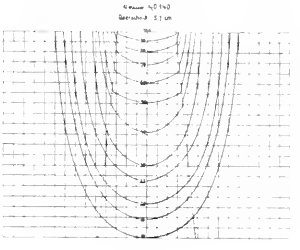
FIG. 5.

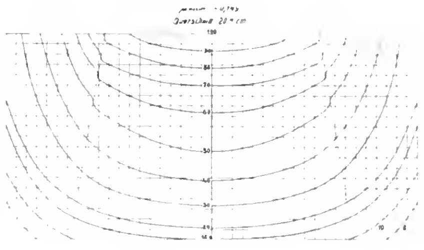
FIG. 6.

FIG. 4. Distribution of intensity with the following factors: Coolidge tube. Voltage about 180,000 volts at transformer; 162,500 volts max. at tube. Filter 0.5 mm. Cu. + 1 mm. Al. Focal skin distance 30 cm. Port of entry 5.7 x 7.6 cm. M in water = 0.166. Transverse section 5.7 cm.

FIG. 5. Distribution of intensity with the following factors: Coolidge tube. Voltage about 220,000 volts at transformer; 200,000 volts max. at tube. Filter 1.3 mm. Cu. + 1 mm. Al. Focal skin distance 30 cm. Port of entry 5.7 x 7.6 cm. M in water = 0.140. Transverse section 5.7 cm.

FIG. 6. Distribution of intensity with the following factors: Coolidge tube. Voltage about 200,000 volts at transformer; 181,500 volts max. at tube. Filter 0.8 mm. Cu. + 1 mm. Al. Focal skin distance 60 cm. Port of entry 20.7 x 27.6 cm. M in water = 0.149. Transverse section 20.7 cm.

us one year to find out an exact method of measuring. Since then we have made thousands of measurements of which I can only give you an idea.

The following figures are an example from the tables published in my Frankfort Institute. If at a distance of 30 centimeters a radiation of a precisely known quality and a treatment field of the size of 5.7 × 7.6 centimeters is irradiated, it is possible to find the intensity of radiation at any point in deeper tissues. *In this figure* the localities of equal intensity are connected by lines, which I will call *equal-intensity curves*. If a diseased area is located *here* I can find the intensity of rays it will receive in percentage of the intensity on the surface. The measurements demonstrated many surprises, which were not thought of before, namely, that the intensities in the center of a radiation field are much greater than at the sides in the same depths. The differences amount to 30-60 per cent. It also was not known that the skin in the surroundings of the radiation field receives a heavy dose from the scattered rays. It was thought that this part of the skin was protected by the heavy lead diaphragm at the tube. The consequence of these studies is a *proper method* of a physically correct treatment to be employed in deep therapy. The method actually employed is as follows. First, the physician must make a careful examination and ascertain the location and extent of the growth or lesion, making a sketch of the same, preferably on transparent paper, and in natural size, showing a cross section in the frontal and in the sagittal planes. Hereafter the distribution diagrams are consulted and the quality of the radiation, the focal distance, and the number of treatment fields required for the case are ascertained.

The transparent sketch placed upon the distribution diagram will enable the intensity of the rays to be ascertained in any part of the treated zone. I can only indicate this method, which looks simple at first but is rather difficult to execute. I have the charts with me and will be pleased to show them to anyone who desires further explanation.

Every roentgenotherapist who has made experiments in therapy will have been puzzled about the problem: What is happening in the deeper tissues? This problem is now solved, but there remains the fact that the human body is not simply a regularly formed geometrical object but a complicated structure, and it is impossible to guess in which direction a ray is passing through the body at a certain setting of his appliance, especially by using the old-fashioned tube stands. It is very difficult to judge the biological effects and to compare results, when

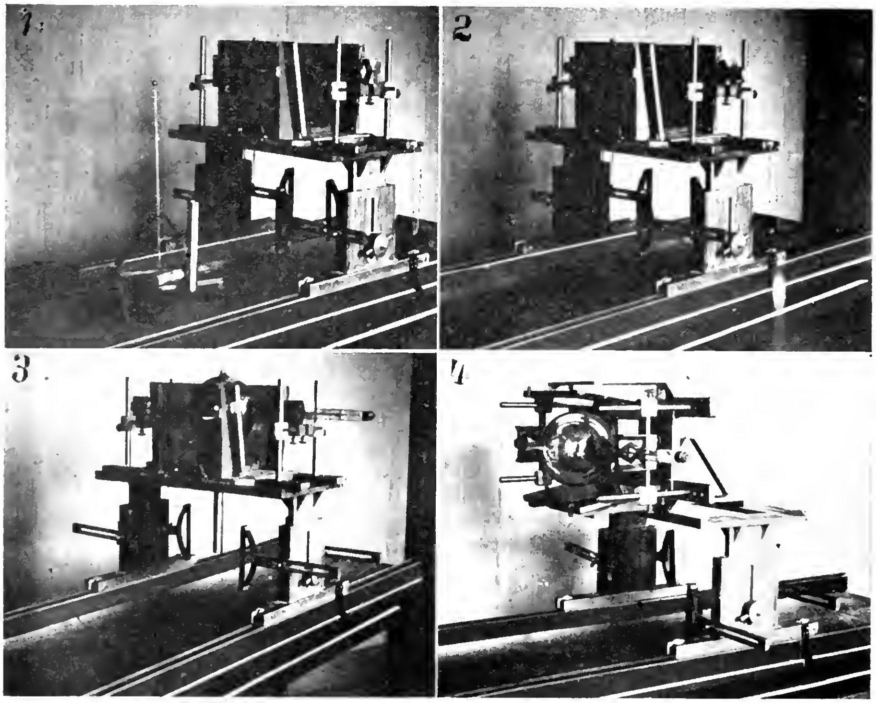

FIG. 7. Treatment appliance.

the same conditions cannot be reproduced. Yet it is possible in many cases to employ artificial means and to change the complicated geometrical form of the body to a simple geometrical form and to use in place of complicated appliances a *simple appliance* (Fig. 7) which has movements only at right angles in a vertical and horizontal direction. I suggest the following method be employed in all cases wherever possible:

1. To make out of the complicated form of the body a form with simple and straight surfaces by using small water-filled rubber bags, a layer of paraffin wax, gelatine, flour paste (dough) or some similar material. When employing such straight forms we find that the distribution of energy within the body tallies very accurately with the physical measurements and tables.

2. To employ an appliance which is set at right angles over the patient and a resetting of which can be reproduced at any time. If we employ these new methods consciously, we will find that some cancer cases cannot yet be successfully cured at all, because the purpose of radiation cannot be accomplished, i.e., to ray every part of the diseased tissue with the same and sufficient intensity. In many other cases we find only one possibility of the treatment and any variation from this would be dangerous. We may neither change the focus distance nor the quality of the radiation, nor the size of the field. The intensity must never be too small nor too large. Whether a case can or cannot be treated successfully should be settled *before* a course of treatment is begun.

The fact that so many different methods of x-ray therapy are employed in the various clinics may be explained by the comparatively recent development of a correct deep treatment.

I wish to point out two objections to this method. There is a difference when air is enclosed within tissue, as for instance the lungs. In my Frankfort Institute, where we are fortunate in having the cooperation of the surgical clinic of Prof. Schmieden and Dr. Holfelder and the gynecological clinic of Prof. Seitz and Dr. Gutmann, we are investigating these cases and ascertaining how the distribution in this case can be compared

with that in water. The second objection may be expressed by saying that *the biological conditions are much more complicated.* I accept this objection, but add that in solving a complicated problem we must take each point and clear the same one by one. The biological problems become clear only after the physical conditions are definitely known, and with this method there is a way. For each case it is possible to arrange the physical conditions so that they may be repeated at any time; hence it becomes possible to estimate the biological effect of a definite physical condition. That has been the aim of my studies on the physical foundations of deep therapy.

PART II

ELECTRICAL AND TECHNICAL STUDIES

At the beginning of the investigations it was ascertained that the conditions for the "homogeneity of the irradiation" could only be fulfilled by the use of very "hard" rays. The hardness of the rays depends upon the voltage on the tube. All recent investigations have proven this fact, and therefore it was necessary to realize these requirements by solving *two* technical problems:

1. The invention and development of roentgen-ray tubes which would stand very high voltages continuously.
2. The invention and development of electrical apparatus which would generate safely very high voltages with great reliability and safety from breakdown.

The solution of the first problem was given in the main part by the inventions of Dr. Coolidge and his co-workers, which are sufficiently well known to all and the results of which I admire greatly.

The other problem, to produce electrical apparatus delivering high voltages continuously and safely, appeared to be easy, but eventually was very difficult. An ordinary induction coil of the old type, for instance, one of a 40 cm. spark, would deliver the necessary voltage but would unfailingly break down if it was used continuously. It was natural that this should happen, according to the laws of the dielectrical strength of insulating materials, because this material as was used was overstrained. Besides, the conditions became uncontrollable through the use of an interrupter which introduced inconstancy of the discharge and rays generated.

It is not difficult to build a transformer for 250,000 volts alternating current and more, and it has often been accomplished, but to build this transformer properly and to make it stand up under continuous use, it has to be *of very large dimensions* and expensive. Its weight would be very great and it would hardly find room in a physician's office.

This is the logical consequence of the high

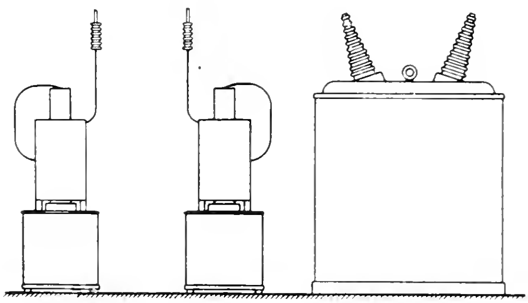

FIG. 8.

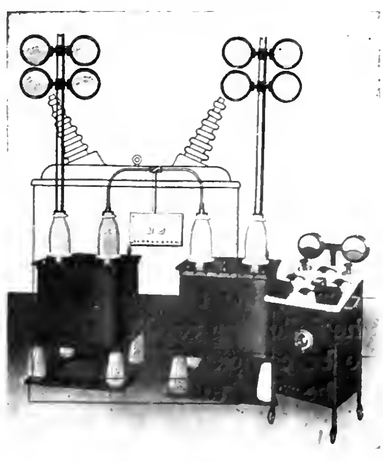

FIG. 9.

voltage which *fixes the dimensions for the insulating materials*, because each material has only got a certain definite electrical stability, which is well known to electrical engineers. Many transformers were built with insufficient insulation. They would work a short time but would eventually break down. Such failures have happened in Germany by the hundreds during treatment work. Imagine further, that even such transformers which are properly dimensioned, for instance, for 250,000 volts continuous service, will lose *their value* as soon as tubes will be constructed that will stand 350,000 *volts and more*. Every ordinarily constructed transformer will lose its value when higher voltages are required.

The most interesting of all the electrical studies of my co-workers and myself, and the most laborious, was the development of voltage generators for 250,000 to 500,000 volts and more, and I have spent many years in developing the transformer that would fulfill the following conditions:

1. To be compact, light and inexpensive and yet be able to produce high voltages with absolute safety and without danger to the insulating material when operating ten hours daily throughout the year.

2. To construct the transformer in such a manner that *by adding new parts* the voltage could always be raised another step, say, to *three hundred thousand* volts and more when such tubes are available. For it is without doubt, and all experiments have proven the fact, that *the conditions for deep therapy are continuously improved with higher voltages*. It may take some years before this voltage is applicable, but it will mean shorter doses and a *greater protection of the skin during treatment*. It would be very painful for the medical man to have to discard his old transformers every time an advance is made in the maximum voltage applied on the tube.

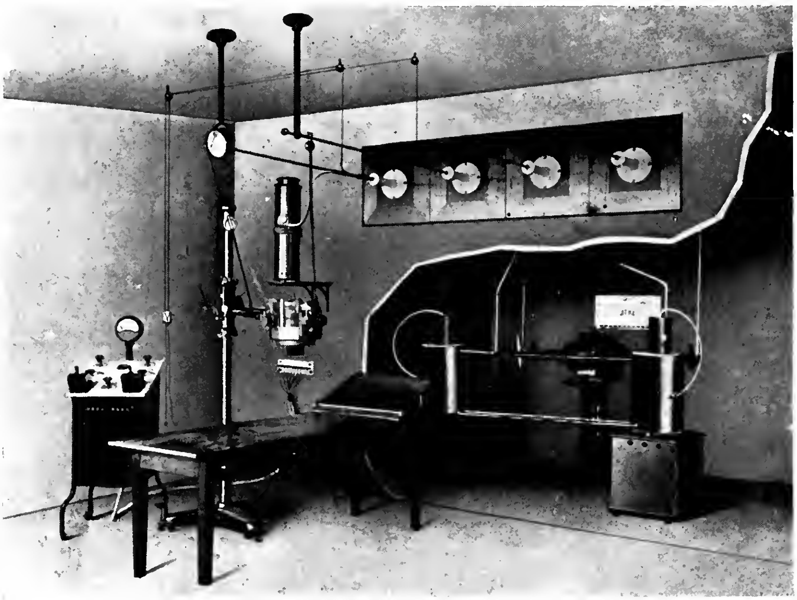

Fig. 10. Apparatus with open iron core transformer.

I solved this problem in 1915 and built up a transformer in 1916 for 500,000 volts, which *voltage I could have raised indefinitely*. The transformer, for instance, is constructed of units, each for 100,000 volts, and I made a careful study of all conditions involved, some of the results of which I wish to show you.

The figures show a comparison of an ordinary 200,000 volt transformer compared with one built for the same voltage under the new principles. This new type has been built since 1916, for therapeutic

purposes, and many hundreds are in daily use, eight to ten hours a day. A puncture from secondary to primary is unknown, whereas there have been very sad experiences with the usual type of transformers which had to be frequently repaired. The new transformers can be built with an open iron core or a closed core equally well, and the transformer is also being built and used for ordinary technical requirements, for testing purposes and precipitation work, they being less than half as expensive, with better conditions of the insulation than the normal type. Many modifications in the construction are possible, but it is rather difficult for the layman to grasp the principle. I will briefly explain the principle, but cannot go into details, as for instance, when to use a single or multiple iron core.

The principle is simply the following: To construct the transformer in such a manner that the coils carrying the highest voltage towards the earth and the primary winding do not have to withstand the full voltage, but that the highest voltage *is carried by and removed to a point where it can do no harm.* This sounds paradoxical, but I shall try to explain it.

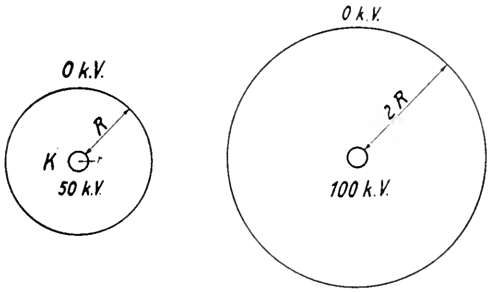

Fig. 11.

In Figure 11, K is a sphere-shaped conductor of a radius *r*, the sphere is at a potential of 50,000 volts in relation to a sphere surrounding it. According to what material is used for insulation to prevent a puncture, the radius R of the outer sphere is fixed. The volume of insulating material required corresponds to the volume of the outer sphere minus the inner sphere, or if the radius of the inner sphere is very small the quantity of insulating material required is $V_1 = 4/3\, R^3 \pi$. If the potential between the inner and outer sphere is raised to 100,000 volts, the space R must be made larger. As the insulating quality of material is reduced with the higher voltage, a larger layer, for instance, of double the thickness of oil, will not be sufficient for the double voltage. But for the sake of simplicity we will assume that it is suffiicient. The volume of insulating material is then formulated thus: $V_2 = 4/3\, 2^3\, R^3 \pi$, i.e., eight times as large. The insulating material required for a double voltage is therefore *eight times greater.*

The idea of my invention was the following:

If we divide up the high tension we can reduce the requirements of insulating material from a geometrical progression into

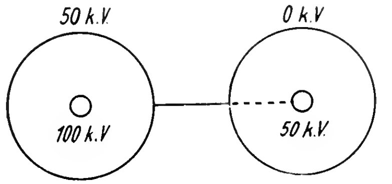

Fig. 12.

an arithmetical progression, as is illustrated in Figure 12. The total voltage, which has to be insulated, is divided up into two systems in series, and in this case only one quarter of the insulating material is required for the above mentioned 100,000 volts.

I shall try to make the idea clearer by using as an example a 100,000 volt roentgen-ray transformer with one terminal grounded, the primary being fed from *the mains.*

In Figure 13, W_1 is the primary winding, W_2 the secondary winding of a high tension transformer. The high tension terminal *a* is grounded. This is an assumption but no essential requirement for this system, and only introduced to make the matter more understandable, the potential being fixed in this case. The low voltage end is fed from the mains and has practically the same potential as *a*, the 100 or 200 volts of the mains playing no part. We now have the peculiar condition that the insulating tube between the primary and secondary

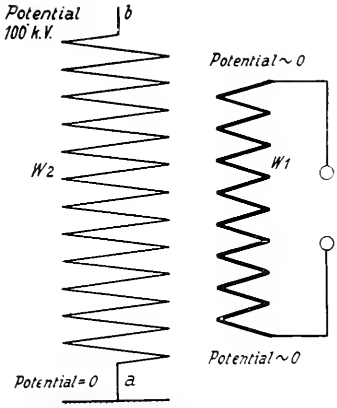

FIG. 13.

winding is carrying all voltages from zero to 100,000 volts along its length and that the lower end at *a* has no voltage whatsoever, but the upper end *b* the maximum voltage of 100,000 volts. At *a* the insulation is wasted and at *b* it has to be considerably intensified to prevent corona and puncture.

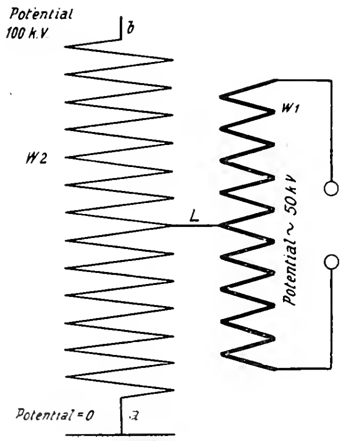

FIG. 14.

It is possible to eliminate the uneven strain on such a transformer and to reduce the insulation material by a device which solves the serious question of insulation in principle. The reason for the high insulating stresses on the corona of our example, is the fact that the secondary winding surrounds along its whole length a primary practically at earth potential, it being connected to the mains. If it were brought up to a potential of half the total voltage, the tension between the high tension pole *b* and the primary could be reduced to half. Figure 14 shows you how this can readily be done, by connecting the middle of the high tension winding with the primary by means of a charging conductor L. The potential of the *primary* is then controlled and constantly held at 50,000 volts; the charging current is exceedingly small, and all insulating material is immediately carrying only half the strain. The question arises, how to get the energy into the primary without changing its potential of 50,000 volts? This could be done by connecting the primary to an insulated generator, but practically it is simpler to feed *through a current transformer* with a ratio of one to one, for instance, but with an insulation of 50,000 volts between windings.

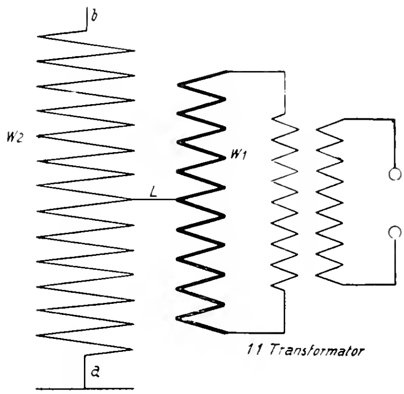

FIG. 15.

This is illustrated in Figure 15. This transformer does not function as a "step-up" transformer, but merely takes away part of the insulating work from the "step-up" transformer, by *changing the insulating factor from a geometrical to an arithmetical progression.*

The above explanation is only an example; the whole thing can be done on a single iron core. But what I wish to illustrate is the fact that this method differs from that of employing two or more transformers in series or parallel.

The principle of the new transformer consists in the following:

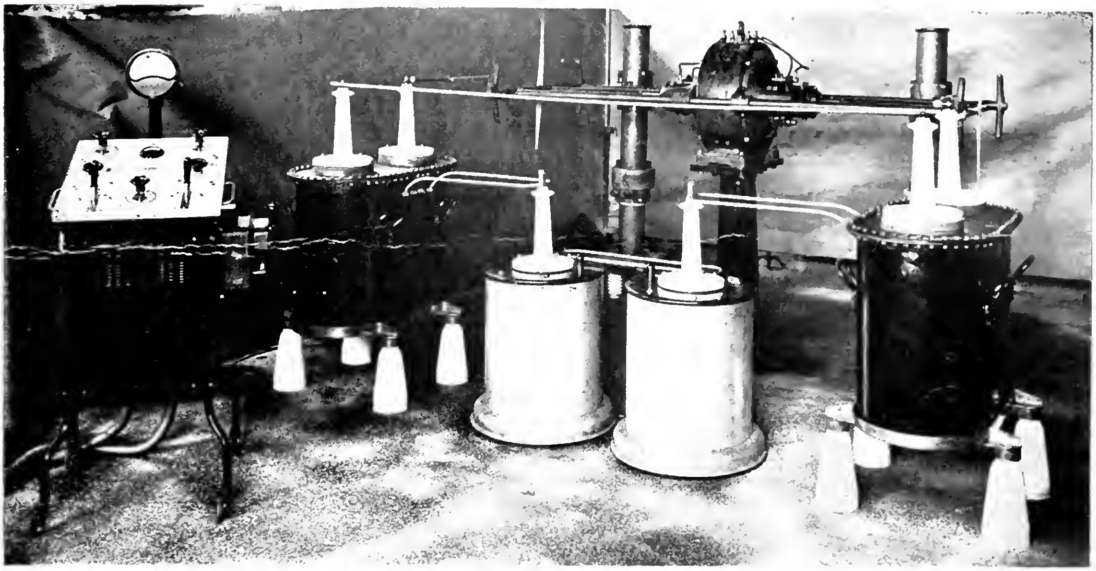

FIG. 16. Apparatus with current transformer and closed core.

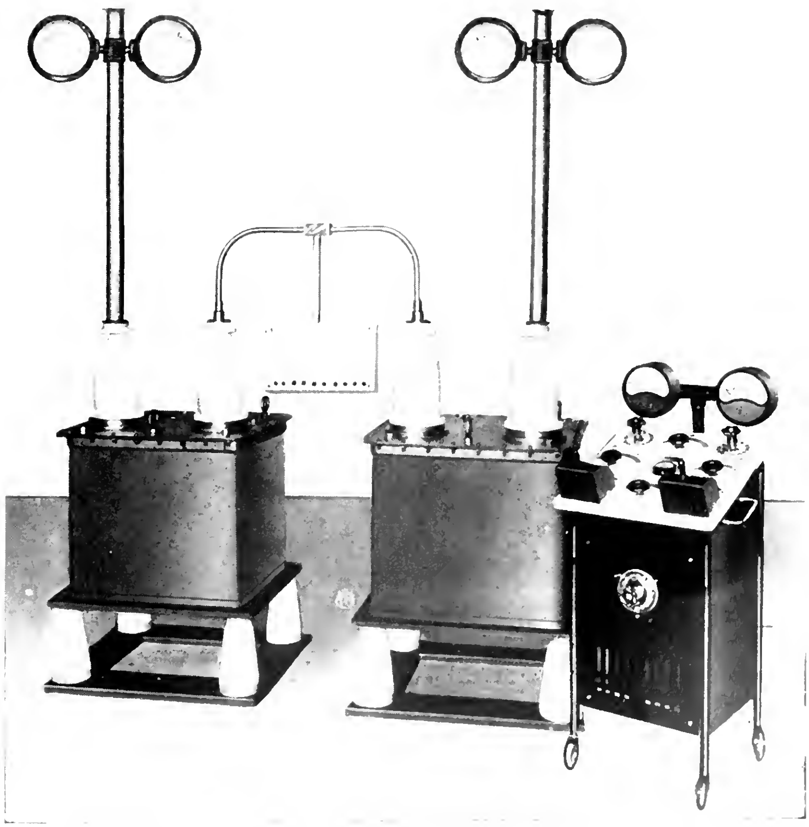

FIG. 17. Apparatus with closed core and current transformer on the same iron core.

First. The separation of the problem of "transformation" from that of "insulation" in the construction of a transformer.

Second. Intentional holding of the energizing winding of a transformer at a different potential from earth than the feeding mains.

Third. Holding the energizing winding at such a potential that the insulating strain from the secondary winding to the primary is *reduced far below the danger zone.*

Fourth. The subdivision of the secondary coil.

What I have tried to explain is only an example; but by the introduction of these principles into the building of transformers, it was possible to introduce such constancy in the work of various clinics that the conditions could be reproduced over and over again. When using the 200,000 volt Coolidge tube, it was possible to work with definitely determined tension and corresponding rays; the feeding alternating current being entirely of the same sine curve. The biological results of the different clinics can now be compared and repeated.

Some of the completed transformer installations built under these principles are shown in Figures 10, 16, and 17.

We have been constructing the type of apparatus with open iron core (Fig. 10) in Germany because of the generally entertained fear of danger to life from high electrical discharges from closed core transformers. The apparatus with current transformer and closed core (Fig. 16) and the apparatus with closed core and current transformer on the same iron core (Fig. 17) are more efficient. The difficulty of producing high voltages is overcome, the transformer can be made smaller and at a lesser cost than heretofore. There is still the necessity of applying this voltage through a rotary or kenetron distributer or rectifier to the tube. We have succeeded in the research laboratory in operating Coolidge tubes at 200,000 volts without rectifier on alternating current, but there are a number of drawbacks. When it becomes possible to send still larger currents through a tube it will be possible to cut down the time of treatment by applying any doses wanted at any part of the body according to the laws of homogeneous irradiation without burning the skin or other sensitive parts.

I do not want to leave the impression that now all cancer growths can be cured. I am a physicist and limit myself to investigating the principal problems by scientific means. I am convinced, and you will agree with me, if I say that wherever nature may show us physical or chemical means by which a chance is given us to help the sick, we must make an exact study of its possibilities. And the opportunity to help will be lost if we do not study the conditions shown us by nature; but it becomes a good chance if we get at a physical method well studied and not left to chance. When to make use of such methods and to what extent I do not know; nature will show this to the medical man. I know that my part of the work was and will remain to sharpen the weapons with which the medical man can fight disease.

THE EFFECTS OF SCATTERED X-RAYS IN RADIOGRAPHY*

By R. B. WILSEY

Communication No. 125 from the Research Laboratory of the Eastman Kodak Company

ROCHESTER, NEW YORK

IN a recent paper on the "Intensity of Scattered X-Rays in Radiography,"[1] the author presented data showing the relatively high intensities of scattered radiation reaching the film under conditions similar to those in the radiography of deep parts. For instance in radiographing through 4 inches of water, it was found that 71 per cent of the radiation affecting the film was scattered radiation; for 6 inches of water this proportion was 83 per cent, and for 8 inches of water, 88 per cent. These values were for a 5 inch spark gap, 20 inch target-film distance, and with no cone or diaphragm limiting the rays other than the circular opening in the lead glass shield surrounding the radiator type Coolidge tube. It is evident that such large intensities of scattered radiation should produce a considerable effect upon the quality of the radiograph. Except in some simple cases it would be difficult to estimate quantitatively what would be the effects of any given intensity of scattered radiation upon the radiographic quality. It was the purpose of the present experiments to obtain some measurements of the effects of scattered radiation under typical conditions, and to compare the effects of reducing scattered radiation with the results obtained by other methods of improving the quality of radiographs of deep parts, such as the use of intensifying screens and reducing the spark gap.

The two physical characteristics of the radiographic image which govern its diagnostic value are its contrast and its definition.† Any sign or detail in a radiograph is distinguishable by reason of its contrast with surrounding areas, just as any object in nature is visible by reason of its contrast in color or brightness with its background. Within certain limits, the greater the contrast of an object with its background, the greater is its visibility. The apparent contrast is also greater when the dividing line between object and background is sharp than when the outline is diffuse, hence the importance of good definition. The better the definition the more information is obtainable about the finer structural details. Contrast in the finer details and definition are closely related; however, it is not the purpose here to analyze the connection between contrast and definition but rather to use the measurement of these factors in comparing the values of various methods in radiographic technique.

The relation of intensifying screens to the problem of scattered radiation is also of special interest; the improvement in contrast produced by intensifying screens in the radiography of deep parts has given rise to the belief that intensifying screens reduce the effects of the scattered rays. Experiments were therefore performed to study the reaction of intensifying screens to scattered rays and to determine how the action of intensifying screens compares with the effects of an actual reduction in intensity of the scattered radiation.

In the experiments upon contrast, a set of artificial conditions were chosen as being fairly typical of those occurring in the radiography of deep parts. The experimental arrangement is illustrated in the diagram shown in Fig. 1. The scattering material was a depth of 6 inches of water contained in a tank 12 inches square; the bottom of the tank was of aluminum 1/32 inch thick. Immersed in this was a block of beef bone 3/8 inch thick and about ½ inch square. The tank rested on a lead sheet 1/16 inch thick, in which was a circular hole 3 inches in diameter. The film in a cassette or exposure

†The influence of the preparation and positioning of the patient upon the diagnostic value of the radiograph is a medical question and is outside the scope of the present investigation.

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

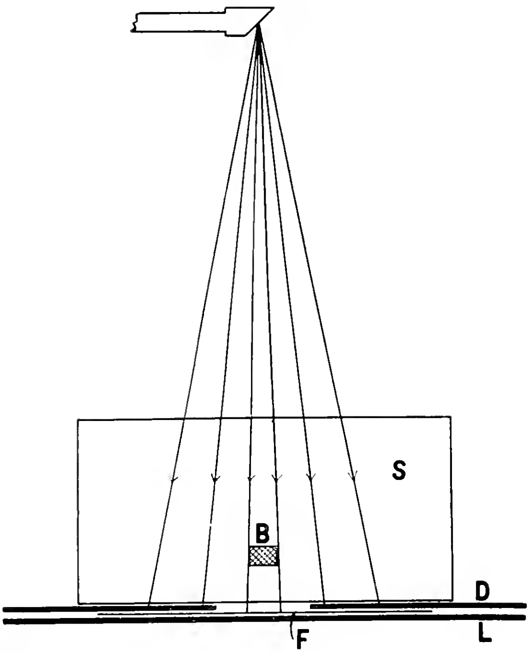

FIG. 1. Diagram of experimental arrangement in experiments on contrast. S, scattering material; B, small block of beef bone; D, lead diaphragm with 3 inch aperture; F, photographic film; L, sheet of lead.

holder was supported directly beneath the lead sheet and could be placed so as to receive the exposure through the 3 inch aperture on any portion of the film; by this means six exposures could be obtained on one 8 x 10 film. The block of beef bone placed in the center of the tank was in the path of the central ray and its shadow fell on the film in the center of the circular aperture in the lead sheet.

The first experiment was carried out to determine the effect of "undercutting" of scattered radiation. When an object embedded in scattering material is close to the film, it absorbs the diffuse rays as well as the focal rays, thereby keeping the ratio of their intensities about the same. If the object is some distance away from the film, scattered rays may pass underneath the object with their intensity unaffected by its presence, while the focal rays are absorbed as much as before. This effect is illustrated in Figure 2. The result is that in the shadow of this object the ratio of diffuse to focal radiation has been increased, as is shown by the following experiment. The block of beef bone, immersed in 6 inches of water, was radiographed at various distances from the bottom of the aluminum tank, the exposures being made upon adjacent portions of one sheet of film. Four such films were made, the exposure conditions being the same throughout: 5 inch spark gap, 3.8 ma., 20 inch target-film distance, and exposure time twenty seconds; the films were given the standard development of five minutes in a tank of Elon-hydroquinone developer at 65° F. The density difference between the shadow of the beef bone and the surrounding area was measured. The mean values from the four films are recorded in Table I. The loss of contrast is quite marked as the section of bone is moved away from the

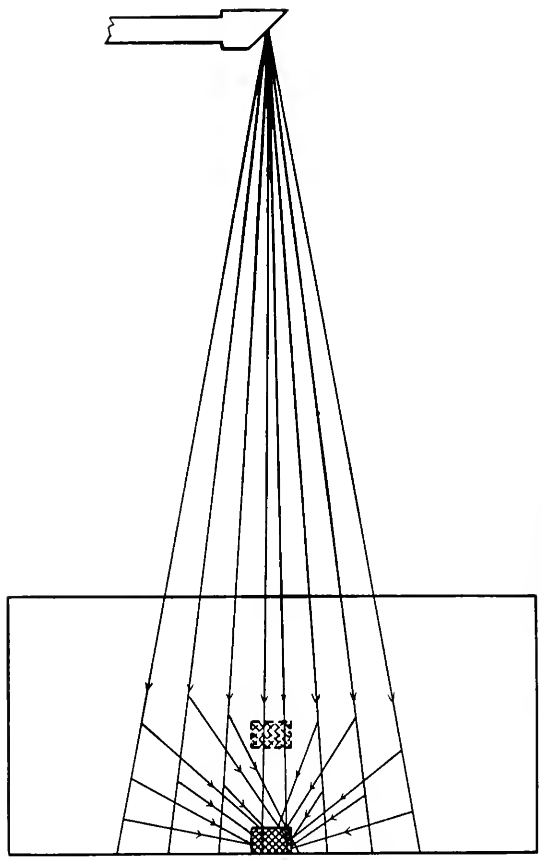

FIG. 2. Diagram illustrating "undercutting" of scattered radiations.

TABLE I

Distance of beef bone from bottom of scattering material	*Density of bone shadow* D_b	*Density due to exposure through water alone* D_w	*Density Difference* $D_w - D_b$	*Relative Density Difference*
0 inch	1.05	1.47	.42	1.00
1 inch	1.26	1.43	.17	.40
2 inches	1.36	1.51	.15	.36
3 inches	1.38	1.50	.12	.28
4 inches	1.39	1.52	.13	.31
5 inches	1.40	1.53	.13	.31

film, most of the decrease occurring within a distance of two inches; for all greater distances, the contrast is practically constant, and has about one-third the value obtained when the beef-bone is close to the film. If there were no scattered radiation the contrast in the radiograph would be independent of the position of the beef bone in the water.

The effects upon contrast of various types of technique were investigated in a somewhat similar manner. Under a given set of conditions the section of beef bone immersed in water was radiographed, a series of exposures being made on successive areas of an 8 x 10 film. The densities of the shadows of the beef bone and of the surrounding areas were measured and the corresponding differences in density between the bone shadow and the suronding area were plotted against the density of the surrounding area; this density difference is a measure of the contrast obtained in the given experiment. Figure 3 shows some curves obtained in this way. The density of film in the shadow of the section of bone is designated by D_b, while the density of the surrounding area, produced by radiographing through water alone, is indicated by D_w. The difference, D_w–D_b, is plotted against D_w. In this case, the section of bone was 2 inches from the bottom of the aluminum tank which contained water to a depth of 6 inches. The tube was run at a 5 inch spark gap with a current of 3.4 ma. and a target film distance of 20 inches; the films were given the usual standard development. Each curve is the result of two such films. Curve 1 was made with only the lead glass shield limiting the rays (image diameter 20 inches); curve 2 shows the effect of diaphragming the image size to 4 inches, and curve 3 the effect of decreasing it to 1¾ inches. Figure 4 shows the effect of double intensifying screens upon the contrast, the exposures being made with a tube current of 10 ma., otherwise the exposure conditions were the same as in the previous experiment. Curve 1 represents the results without

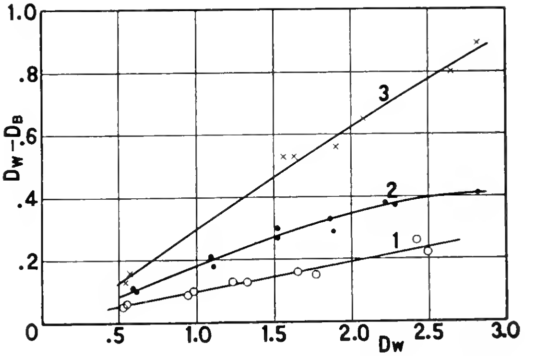

Fig. 3. Curves showing improvement of contrast produced by circular diaphragms over the scattering material. Each abscissa value is the density of film exposed through the water, and the corresponding ordinate is the contrast between that density and the density in the shadow of the beef bone. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter 4 inches; and Curve 3, image diameter 1¾ inches.

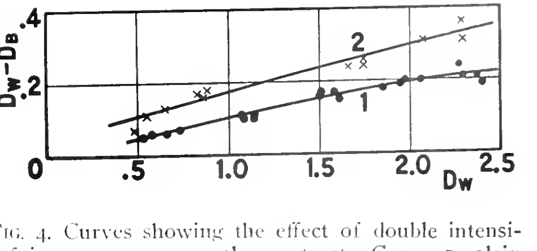

Fig. 4. Curves showing the effect of double intensifying screens upon the contrast; Curve 1, plain duplitized film, and Curve 2, duplitized film between double screens.

screens and curve 2 the values obtained with the double screens. The average density difference ($D_w - D_b$) obtained with intensifying screens in this case is 60 per cent greater than that obtained with the film alone.

The effect of diaphragms in improving the contrast is not always as great as is indicated by the curves of Figure 3; the effect was found to vary with the distance of the beef bone from the film. The improvements in contrast produced by various sizes of cones or diaphragms, by double intensifying screens, and by reducing the spark gap from 5 inches to 3 inches, with the beef bone at various distances from the film, are shown in Table II. A thickness of 6 inches of water was the scattering material. The diameter of the image as limited by the cone or diaphragm, with the target-film distance kept at 20 inches, is given as a measure of the degree of diaphragming of the rays.

The average density differences were obtained from curves like those shown in Figures 3 and 4; that obtained upon plain duplitized film with a 5 inch spark gap and image diameter of 20 inches was taken as unity in each case so that the figures given in this table represent the magnification of the contrast produced by variations from this technique.

The effect of double screens upon the contrast is seen to be about the same for each position of the beef bone; (Exp. No. 5) the variations in the observed values cannot be taken as indicating definite differences in contrast. The same can be said of the effect of reducing the spark gap to 3 inches (Exp. No. 4). The improvement in contrast produced by diaphragming down (Exp. Nos. 1-3) is greatest when the section of bone is some distance from the film and is greater in this case than the effect obtained with intensifying screens. When the beef bone is close to the film, diaphragming has much less effect on the contrast, the effect obtained in these experiments being less than that obtained with intensifying screens or by reducing the spark gap; even in this case if more of the scattered rays were removed, the contrast would probably exceed that obtained by the other methods. The values obtained in these contrast experiments would have been somewhat different if an object of different absorption had been used instead of the section of beef bone; however, the character of the results illustrates quite clearly the action of the scattered rays, and shows the degree of improvement possible when their intensity is reduced.

TABLE II

Exp. No.	*Spark Gap in inches*	*Tube Current (ma.)*	*Image Diameter in inches*	*Intensifying Screens*	*Relative Density Differences* Beef Bone in bottom of 6" water	Beef Bone from bottom 1"	2"
1	5	4	20.0	none	1.00	1.00	1.00
2	5	4	4.0	none	1.15	1.96	1.80
3	5	4	1.75	none	1.35	3.07	3.11
4	3	7	20.0	none	1.46	1.53	1.55
5	5	10	20.0	double	1.54	1.76	1.61

Scattered radiation reduces the contrast in all parts of the radiograph; its greatest effect is upon portions of the subject at some distance from the film so that portions near the film show up most clearly and the portions away from the film show less clearly or not at all. The effect of reducing scattered radiation is to improve most the contrast in portions of the subject away from the film, so that all portions of the subject show up in the radiograph more nearly according to their true absorption for x-rays. Greater contrast can be secured by a reduction of the scattered radiation than by the use of intensifying screens or by reducing the spark gap; this advantage is greatest for portions of the subject at a distance from the film.

An experiment was performed to determine the effect upon contrast of using a filter between the scattering material and the film. The beef bone was immersed in a depth

of 6 inches of water at a distance of 1 inch from the bottom of the tank. Four films with six different exposures on each were made without the filter and four similar films were made with a filter of .001 inch of lead foil between the scattering material and the film. All the films were developed alike. The average density difference obtained with and without the filter agreed within one per cent. Such good agreement is accidental, but it shows that a filter used in this way is of no appreciable benefit and its only effect is to increase the exposure. In the previous investigation it had been found that this thickness of lead foil reduced the proportion of diffuse radiation from 83 per cent to 79 per cent. Owing to the absorption of softer rays in the lead foil the image is produced by harder rays which give less contrast and counteract the improvement to be expected from the lower relative intensity of scattered radiation.

Scattered radiation is not reduced by giving a light exposure. Under any set of conditions, the scattered radiation reaching an area of the film is a certain definite proportion of the total radiation on that area and whenever any radiation at all is recorded by the photographic surface, the scattered rays produce their definite proportional effect. The curves which have been exhibited (Figs. 3 and 4) show that the contrast ($D_w - D_b$) increases with exposure; underexposure simply adds its effect to the scattered radiation in reducing contrast.

The values of various techniques in showing up very faint differences in absorption were compared by radiographing a disk of celluloid 1/10 inch thick immersed in a depth of 6 inches of water at a distance of 2 inches from the bottom. A radiograph made with a 5 inch spark gap, 20 inch target-film distance, and a 20 inch image diameter failed to show the disk; it was not shown by the use of double intensifying screens, nor by reducing the spark gap to 3 inches. However, it could be detected when the image size was diaphragmed to 1¾ inches and was easily visible when the image diameter was reduced to ¾ inch (at 5 inch spark gap with plain duplitized film).

A celluloid disk of double the thickness (1/5 inch) immersed in 6 inches of water at a distance of 2 inches from the bottom was also radiographed by these various techniques. The shadow of the disk could not be detected with any certainty in the radiograph made in the ordinary way with the 20 inch image diameter. An extremely faint shadow was produced with double intensifying screens; the shadow made with the 3 inch spark gap was also scarcely perceptible. By diaphragming the image to 4 inches in diameter, the shadow obtained was quite definite, and further improvement was obtained by diaphragming the image to diameters of 1¾ inches and ¾ inch.

These experiments upon detecting faint difference in x-ray absorption are very critical tests of the value of any type of technique. Usually it is much easier to increase contrasts in details that are already visible in a photograph than to bring out details that previously could not be detected. Reducing the intensity of scattered radiation, in addition to improving the general appearance of the radiograph, brings out definitely faint differences in absorption that cannot be shown by other means at our disposal and therefore enables new information to be obtained which was not available by other methods.

The double intensifying screen is not so suitable for detecting faint differences in density when the finest definition is involved. In radiographing a thin layer of cardboard, with no scattering material present, the intensifying screens did not show up the cardboard as well as the film alone, owing to the fact that the film showed clearly the sharp outlines of the cardboard whereas the screens did not; the apparent contrast between two adjacent areas is greater when the dividing line is sharp. But intensifying screens are intended only for the radiography of thick parts, where the definition obtainable as a rule can be recorded satisfactorily by good intensifying screens. Under such conditions the superior contrast produced by double screens gives

them a slight advantage in detecting faint differences in absorption. However, better results are obtained when the scattered radiation is sufficiently reduced. When scattered radiation can be eliminated to a considerable extent, single screens will be better able to take advantage of the improved definition and will probably give all the contrast necessary.

The data in Table II show that the action of intensifying screens is not exactly equivalent to a reduction in intensity of the scattered rays; intensifying screens appear to give the same magnification of the contrast, regardless of the distance of the object from the film, whereas the removal of scattered radiation has a very different effect accordingly as the object is near the film or away from it. To determine how much less intensifying screens record the relative intensity of the scattered rays than does duplitized film, measurements were made by the method described in the former paper[1]. A small lead disk was supported at the surface of the water. In the shadow of this disk only diffuse rays could affect the film, and outside its shadow the total of diffuse and focal radiation fell on the film. The relative intensities of diffuse and total radiation recorded by the combination of film with intensifying screens was measured by the method previously described, the relative intensities being determined by the exposures required to produce equal densities on the film. When films alone were used, the exposure was varied by varying the time with x-ray intenstiy constant, on the assumption that a change in the exposure time is equivalent in its photographic effect to the same proportional change in intensity. This assumption holds true for plain duplitized film under ordinary radiographic conditions, but it does not hold for intensifying screens. When screens are used, a given increase in x-ray intensity produces a greater photographic effect than the same proportional increase in the exposure time. The time and intensity required to produce a given photographic density are not inversely proportional to each other. Consequently serious errors would occur if in the case of intensifying screens the time alone were varied and the intensities assumed inversely proportional to the times required to give equal photographic densities. Therefore in these experiments with intensifying screens, the exposure time was kept constant and the x-ray intensity alone was varied by control of the tube current. The voltage on the tube, as determined by the sphere gap for each current, was kept constant. The relative intensities of diffuse and total radiation were taken as inversely proportional to the tube current required to produce equal densities with the two radiations, all other conditions remaining constant. The radiator type Coolidge tube was run at 60 kilovolts with target-film distance of 20 inches. A 6 inch depth of water enclosed in a 12 x 12 inch aluminum tank was the scattering material.

The data obtained on three types of intensifying screens, A, B, and C, are given in Table III; each value is the mean obtained from ten to twelve films with six exposures on each film. The screens were used in an aluminum cassette. The results obtained with them are compared with the values for plain duplitized film loaded in the same cassette. The value for film loaded in cardboard holders is also given. The aluminum top of the cassette acts as a filter and itself reduces slightly the ratio of diffuse to total radiation.

TABLE III

Type of Intensifying Screen	*Ratio Diffuse to Total Radiation*	*Ratio Diffuse to Focal Radiation*
Duplitized Film, no screens, in cardboard holder	.83	4.9
Duplitized Film, no screens, in aluminum cassette	.81	4.3
A Single Screen	.80	4.0
A Double Screen	.78	3.5
B Single Screen	.79	3.8
B Double Screen	.77	3.3
C Single Screen	.80	4.0
C Double Screen	.77	3.3

These values are independent of any con-

trast effects produced by the screens; they show that intensifying screens do record the scattered radiation less in proportion to the direct rays than plain duplitized films. The effect is not large, but enough to produce a noticeable increase in contrast. The use of double intensifying screens reduces the ratio of diffuse to total radiation from 4.3 to 3.4 a decrease of 21 per cent. In every case the double screen is seen to be slightly more effective than the single screen. The three types give practically the same results; the small differences may be attributed to experimental error. There is no doubt that part of the increased contrast given by intensifying screens is due to their lower relative sensitiveness to scattered rays. However, it is evident that intensifying screens are far from being a solution of the problem of scattered radiation inasmuch as they lower only slightly the proportion of scattered radiation reaching the film; they still leave much room for improvement. The experiments on contrast showed that a higher contrast could be obtained by reducing the intensity of scattered rays than by the use of intensifying screens. However, the gain in contrast produced by a reduction of the scattered rays can be enhanced by the use of intensifying screens, and the screens tend to offset the loss in x-ray intensity.

For the experiments in definition, a definition test object was made up of 16 wire gauzes ranging from 110 to 280 meshes per inch. The spacing of the meshes was measured with a micrometer microscope. Each gauze was about ¼ inch square and the whole set was mounted together between two squares of cardboard. The definition test object was radiographed at various distances from the film and with varying amounts of scattering material. A medium focus radiator type Coolidge tube was used, running at 60 kilovolts with a target film distance of 20 inches. The films were given the usual standard development of five minutes in Elon-hydroquinone developer at 65° F. The best definition obtainable under each set of conditions is recorded in Table IV. In some cases the finest gauze available, 280 meshes per inch, was not fine enough to test the limit of definition, and in these cases the result is indicated by >280 (greater than 280); in other cases, the coarsest mesh could not be resolved and the result is indicated by <110 (less than 110). The radiographs were examined with a small magnifier (10x) and the finest gauze whose meshes could be distinguished over its whole area was taken as representing the best definitions obtainable under the conditions of the experiment; special effort was made to maintain the same criterion of judgment in examining all the tests.

The differences between the definition with and without the water show the large effect produced by the scattering material. Probably part of the loss in definition is produced by selective absorption of the softer rays, but undoubtedly most of it caused by scattering. As the test object is moved away from the film, the definition is diminished by reason of the size of the focal spot, but it is reduced a great deal more by the scattered radiation.

When the test object is away from the film, the "undercutting" of the scattered rays has a serious effect upon definition, as is shown by the large differences in definition when the test object is next to the film and when it is 1 or 2 inches away. Reducing the intensity of the scattered rays by means of diaphragms produces a marked improvement in the definition.

Tests of the definition of intensifying screens made without scattering material have shown that their definition is much poorer than that of plain duplitized film.[2] It would be expected that in radiographing thick parts this difference would be much less marked and that the differences between various screens in definition would be even less noticeable.

To determine the effect of intensifying screens upon definition in radiographing through a scattering material, comparisons were made between various screens and duplitized film, using a variety of conditions to secure a wide range of definition values. The data from these experiments are re-

TABLE IV

Distance of definition test object from bottom of tank	*Depth of water (in inches)*	*Definition in meshes per inch* 20 inch image diameter	4 inch image diameter	1 3/16 inch diaphragm at surface of water	*Definition with no scattering material*
	1	>280	>280	>280	
	2	>280	>280	>280	
	3	>280	>280	>280	
0	4	280	>280	>280	>280
	6	230	>280	>280	
	8	195	280	>280	
	10	150	230	>280	
	2	170	190	205	
	3	165	180	195	
1	4	155	170	190	280
	6	130	160	175	
	8	110	145	165	
	10	<110	130	...	
	4	110	120	175	
2	6	<110	<110	150	205
	8	<110	<110	<110	

corded in Table V, for three types of screens, A, B, and D.

It will be noted that the differences in definition among the various screens and duplitized film show up under most of the conditions tried; but when the conditions are such that poor definition is obtained these differences become small, practically negligible, as is shown where the test object is 1 inch from the bottom of 6 inches of water. The better the definition, the more pronounced are the differences in the definition of the various screens.

In radiographing the thickest parts, where the portions of chief interest are usually some distance from the film, it would appear that the limitations of screens in the matter of definition are not of much importance; but where the conditions do permit of good definition, as for instance when it is possible to bring the portions of chief interest close to the film or when scattered radiation is considerably reduced by means of a diaphragm, then a screen having good definition is of definite advantage, and if the best possible definition is demanded, screens should not be used, provided, of course, that satisfactory immobilization can be secured. In reducing the intensity of scattered rays by a diaphragm the increase in exposure required makes it necessary in most cases to use intensifying screens; in order to secure the fullest advantage from the reduction in the scattered rays, the screens employed should have the best possible definition.

In the tests of the definition of the screens without scattering material, the various

TABLE V

Distance of test object from bottom tank	*Depth of water in inches*	*Definition* Duplitized film without screens	A single screen	A double screen	B single screen	D double screen
0	0	>280	>280	280	>280	230
	6	230	185	175	120	120
	2	170	155	150	130	115
	3	165	140	130	115	110
1	4	155	120	120	110	110
	6	130	110	110	<110	<110
	8	110	<110	<110	<110	<110

screens used were in the following order as regards excellence of definition:

1. A, single
2. B, single
3. A, double
4. D, double

When scattering material was interposed, the A double screen was found to have better definition than the B single, whereas the reverse was the case without scattering material. This observation seemed very peculiar, but several repetitions of the experiment gave the same result. The explanation of this fact will probably require a knowledge of the factors which govern the definition of intensifying screens, such as the sizes and distribution of the particles of fluorescent material and the scattering of light and x-rays within the fluorescent layer.

It is evident that tests of the definition of intensifying screens should include exposures made through a scattering material to determine the value of the definition of the screens under conditions of actual use.

In the matter of definition, also, it is found that intensifying screens have an effect upon the radiograph other than that of a reduction of scattered radiation; intensifying screens tend to give poorer definition than is obtained without them, while a removal of scattered rays improves the definition. The primary purpose of intensifying screens is to diminish the exposure, and in doing so they often assist greatly in overcoming the loss in definition from motion of the patient. Intensifying screens can be used with advantage in the examination of many types of cases and often they are essential for a successful radiograph. To point out their limitations, however, is not to disparage their value when properly used. The roentgenologist, with a knowledge of the characteristics of his screens and of the requirements of the case under examination, must decide in each case whether or not intensifying screens are likely to give the best result.

From this series of experiments, it is apparent that there is no adequate substitute for an actual reduction in intensity of the scattered radiation, other methods of increasing the contrast do not have the same effect as the removal of scattered rays, and do not give as much improvement in contrast or definition as can be obtained by a sufficient reduction of the scattered radiation. Most important of all, in the detection of faint differences in absorption, the removal of scattered radiation can give results far superior to any other technique.

The effects of tube voltage, filters, and intensifying screens upon the proportion of scattered radiation affecting the film indicate that the scattered rays are but little different in quality from the primary rays, and therefore there is no prospect of effectively separating the scattered rays from the primary rays by filters having a selective absorption, or by photographic materials having a special type of sensitiveness. The only method of reducing scattered radiation to any considerable extent is by the use of diaphragms. These may restrict the scattering by limiting the volume of material rayed, or they may be arranged, as in the case of the Bucky diaphragm, to prevent the scattered radiation from reaching the film.

Small cones or diaphragms placed between the tube and the scattering material are suitable for some experimental purposes, as in the present investigation, but they have only a limited application in practical radiography on account of the small sizes of radiographs they allow. What is required is a method of effectively reducing scattered radiation over a large area. The double shot method, developed by Dr. L. G. Cole, is illustrated in Figure 5. One slot in a large sheet of lead is above the scattering material, the other between the scattering material and the film. They are moved simultaneously in a horizontal direction, the two slots being kept in line with the focal spot which is stationary. The exposure is made through these two slots as they move along. Dr. Cole employed also a third slot near the tube to screen off radiation from other parts of the tube than the focal spot. He found that this method gave a considerable reduction of the intensity of the scattered rays and produced

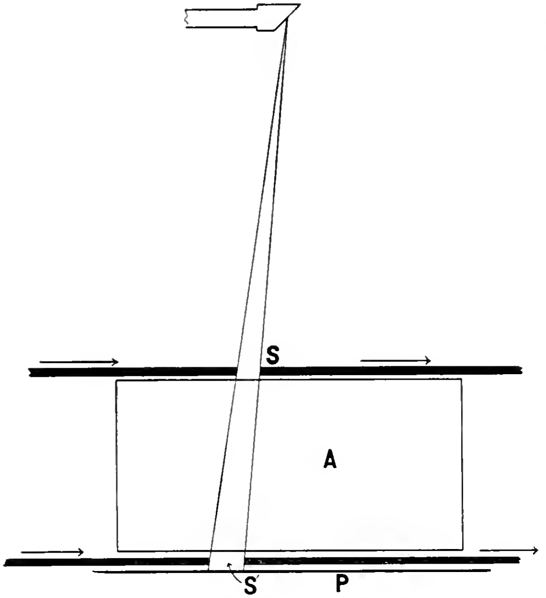

FIG. 5. Diagram illustrating the double slot method of reducing scattered radiation over a large area, the slots S and S′ in sheets of lead are placed above and below the scattering material as shown and are kept in line with the focal spot while being moved in a horizontal direction. The slot S′ moves between the scattering material A and the photographic surface P.

great improvement in radiographic quality. However the method required such heavy continuous exposures as to make it impracticable with the ordinary *x*-ray tubes. A water-cooled tube would be necessary to get a radiograph in one continuous exposure.

Dr. Potter's modification of the Bucky diaphragm[3] has proved itself to be a very practical method of reducing scattered radiation over a large area and has achieved a well-deserved popularity.* The remarkable results obtained with the Potter-Bucky diaphragm have done more than anything else to demonstrate the improvement afforded by a reduction of the scattered rays. There can be no doubt that it is the greatest advance in radiographic technique in recent years.

In conclusion, it must be pointed out that the increased exposure required when scattered radiation is reduced constitutes an additional source of danger. Greater care must be exercised to avoid an *x*-ray burn. The Potter-Bucky diaphragms now in use require about three or four times the normal exposure, which means that one third or one quarter as many radiographs can safely be taken as by the ordinary technique without the diaphragm. It is practically essential in most cases that intensifying screens be used with the Bucky diaphragm to reduce this danger.

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*An investigation of the efficiency of the Bucky diaphragm principle will be presented in an early issue of this Journal. This will show the influence of various factors in the design of the grid upon the effectiveness of the diaphragm.

THE KEARSLEY STABILIZER*

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THE milliamperage which will pass through a hot cathode roentgen-ray tube increases very rapidly with the temperature of the filament and hence with the heating current. To avoid fluctuations in milliamperage, in all of the early installations a storage battery was used as a constant source of heating current. The storage battery called for a good deal of attention and was, for various reasons, far from ideal for the purpose. It has been almost completely superseded by the "filament transformer." This has been more convenient, but owing to line-voltage fluctuation, has resulted in greater variability in the milliamperage passing through the tube.

In an earlier article[1] the author has alluded to attempts to hold the filament current constant by means of magnetos, boosters, iron wire ballasts, and various other devices, and finally by means of a special constant potential transformer. The last named device had no time lag and funcioned very well, but took a pretty heavy current—often 18 to 20 amperes.

The above efforts were all directed toward the suppression of fluctuations in milliampereage due to causes external to the tube itself. Even with constant filament temperature, changes in milliamperage may take place due to vacuum changes in the tube. Certain gases, when liberated from the electrodes or glass walls, will cause a diminution in the electron emission from the filament, and hence in the milliamperage.

Mr. W. K. Kearsley, Jr., has devised a stabilizer[2] which works on an entirely different principle and is much more ambitious in its aim. It does not attempt to hold filament current constant but, rather, automatically varies it as required to maintain constant milliamperage through the tube. It accomplishes this result regardless of line-voltage changes and regardless of internal vacuum changes. The following description of this stabilizer is taken from Mr. Kearsley's article:

"The stabilizer is operated directly by the high tension current which flows through the x-ray tube. Any change in this high tension current causes the stabilizer to act directly on the current flowing through the filament. If for any reason the high tension current through the tube tends to drop, the stabilizer immediately increases the filament current sufficiently to prevent the drop. The same holds true for a rise in high tension current; the filament current in this case is immediately lowered enough to keep the milliamperage at the desired value.

Figure 1 shows diagrammatically the principle upon which the stabilizer operates. A is an electromagnet which is connected directly into the high tension circuit. All of the high tension current passes through this magnet. B is an iron armature which is free to vibrate when current passes through the

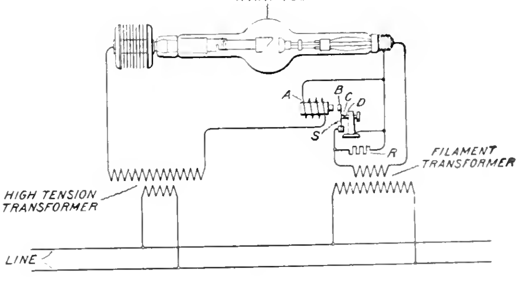

FIG. 1.

[1] A summary of physical investigation work in progress on tubes and accessories. AM. J. ROENTGENOL., December, 1915, p. 891.

[2] W. K. KEARSLEY, JR. A new type of stabilizer for use with the Coolidge tube. This was described by Mr. Kearsley in a paper read December 15, 1920, at the Chicago meeting of the Radiological Society of North America.

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

magnet A. C and D are contacts. One of these is fastened to armature B and moves with it, while the other remains fixed. These contacts are in series with the filament in the x-ray tube. There is also a small fixed resistance R, which is connected across the wires leading to the contacts. S is a spring which pulls the armature away from the magnet.

The operation is as follows:

We will assume that a small current of say 1 or 2 ma. is allowed to flow through the tube and magnet A. This current exerts a pull on the armature B, but if the spring S is sufficiently strong the armature will not move. Now if the current is increased to say 10 ma. the magnet overcomes the tension of spring S, and the armature moves toward the magnet. The instant the armature moves, contacts C and D separate, and the current, which was flowing through these contacts to the filament, now has to pass through the small resistance R. This resistance immediately lowers the filament current, which, of course, keeps the high tension current through the tube from going higher. This operation is repeated for each cycle of high tension current passing through the tube.

It will be seen then that the high tension current through the tube is controlled by the tension of the spring S. If 20 ma. is desired instead of 10 ma. the tension of spring S is increased. More current now has to flow through the magnet before the contacts will separate. Instead of changing the tension of the spring to get more or less current through the tube, the magnet may be moved farther away from, or closer to, the armature B, which accomplishes the same result. The same result may also be accomplished by varying the number of turns employed, through the use of suitable taps, in the magnet coil.

Figure 2 shows another method of connecting the stabilizer to the tube circuits. In this case the magnet coil is connected to the center taps brought out from the high tension winding of the transformer, and the contacts C and D are inserted in series with the primary of the filament transformer.

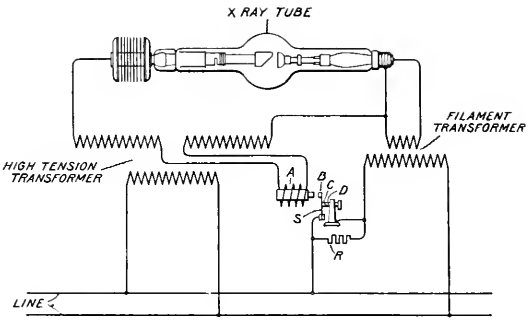

FIG. 2.

The operation is the same in either case. On those transformers having no leads brought out from the center point of the high tension winding, it is necessary to connect the stabilizer in the high tension lead to the cathode of the tube as shown in Figure 1. In this case the stabilizer becomes part of the high tension circuit.

Figure 3 shows an experimental model of the stabilizer.

Table I shows the effect of line-voltage variations on a tube without stabilizer, and the same tube with the stabilizer in circuit.

TABLE I

Without Stabilizer		*With Stabilizer*	
Volts	*Ma.*	*Volts*	*Ma.*
77	2.2	70	2.00
80	3.3	77	2.00
82	4.3	84	2.05
84.5	6.0	87	2.05
86.5	7.0	·90	2.05
89.5	8.4	93.5	2.05
91.0	10.0	96.5	2.05
92.5	11.5	99	2.05
95	13.8	103	2.05
96.5	15.0	106.5	2.05

The stabilizer in this case was set for 2.0 ma.

Table II shows how the stabilizer maintains the current through a radiator type tube during a long exposure. The tube was first connected to a filament control rheostat in the regular way and the current adjusted to 10 ma. Readings were then taken every half minute up to three minutes. The tube was then allowed to cool and the stabilizer connected in circuit. Current was adjusted to 10 ma. and readings were taken again.

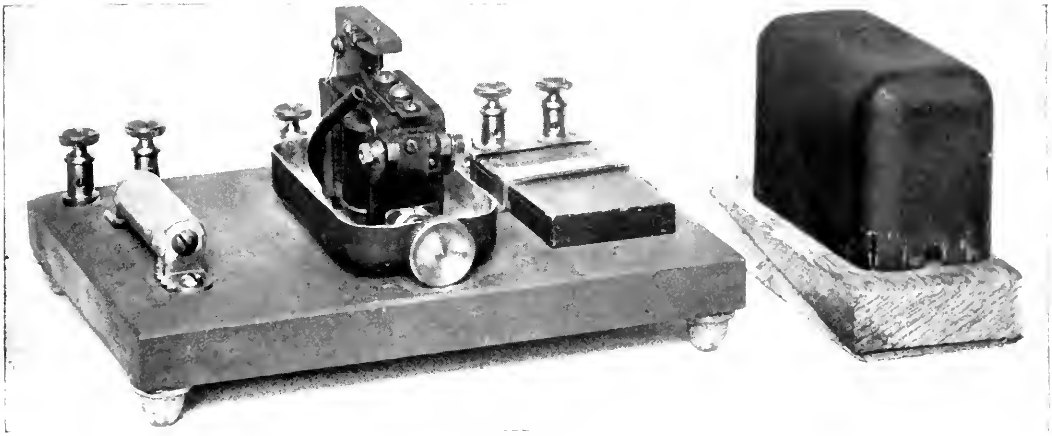

Fig. 3.

TABLE II

Without Stabilizer Time	Ma.	*With Stabilizer* Time	Ma.
0 Min.	10.0	0 Min.	10
½	9.6	½	10
1	9.3	1	10
1½	9.0	1½	10
2	8.7	2	10
2½	8.1	2½	10
3	7.0	3	10

Figure 4 shows curves made with an oscillograph. The tube was of the self-rectifying type. The lower curve represents a high tension current of 15 ma. through the tube and the upper one the filament current taken at the same time. The small irregular lines in the filament current curve show the points at which the stabilizer contacts opened to prevent a further rise in milliamperage through the tube. It will be noticed that there is a break in the filament current curve for each cycle of current through the tube. This shows that the vibrating armature vibrates in synchronism with the alternating current supplying the tube. This is important. If the armature did not vibrate in synchronism, the filament current would not be adjusted to the correct value on some of the cycles, which would cause a variation in the milliamperage through the tube.

That the stabilizer does produce an even flow of high tension current through the tube is shown by evenness of the peaks of the waves in the upper curve, which is the curve of the high tension current."

There are many applications which can be made of the new device.

It will make it easy to combine fluoroscopy with radiography, as, by means of the stabilizer and a suitable switch, the change can instantly and surely be made, even in the dark, from a fluoroscopic to a radiographic load.

It will eliminate one of the complications in the manipulation of a stereo-fluoroscope,

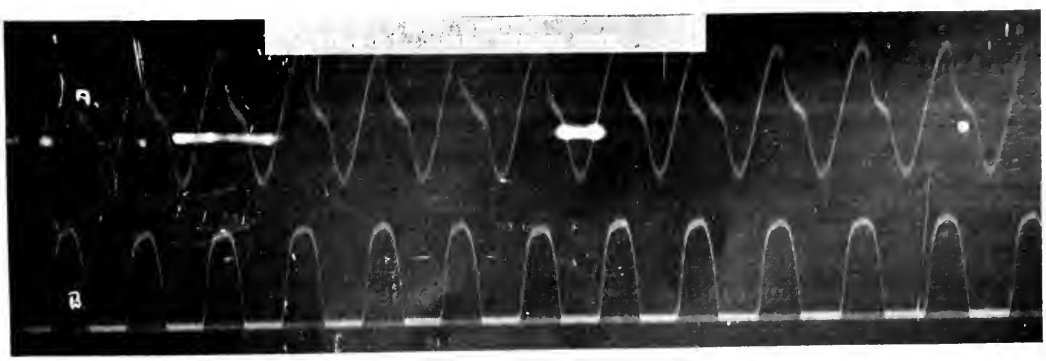

Fig. 4.

as, by its use, the two tubes can be made to maintain constantly and automatically the same millamperage.

It will increase the allowable radiographic load on a given size of focal spot. For it will make it unnecessary to test a tube and will in this way make it possible to start the actual exposure with a cooler target. It will, furthermore, render it unnecessary to allow a large factor of safety to guard against inaccurate adjustment of filament temperature and against inaccurate measurement of milliampereage.

It will be of great value in the administration of accurate dosage in therapy, especially where a technique is employed which involves a long time of treatment.

It should reduce puncturing troubles with both tubes and high tension generators, by reducing the surges attendant upon sudden changes in milliamperage.

It will be very helpful with direct-current installations where, with heavy loads, there has often been a marked drop in the alternating current voltage as the load came on the rotary. Where this drop is greater than can be safely handled by the stabilizer, a little booster can be added.

A SUGGESTION FOR IMPROVING THE VISIBILITY OF THE APICAL FIELD ON THE CHEST RADIOGRAM*

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THE lung markings in the apical field on the chest roentgenogram may be more or less masked by the shadow of the clavicle. This is an obstacle to the early roentgenographic diagnosis of tuberculosis, since in this disease the initial shadows usually appear at the apex.

The closest proximity of the lung apex to the plate at the time of roentgen-ray exposure is generally believed to be essential for the best definition of the apical lung markings. To this end the shoulders of the patient are brought in contact with the plate. The effectiveness of this procedure for the object desired is open to question. The apex of the lung is enclosed in the bony framework forming the upper aperture of the chest. This aperture is bounded anteriorly by the upper portion of the manubrium sterni. Consequently, once the tissues overlying this portion of the sternum rest on the plate, closer approximation of the lung apex to the plate is not possible owing to the inflexibility of the bony ring. The distance of the apex from the plate remains unchanged, irrespective of the position of the shoulders. To rest the shoulders on the plate necessitates their elevation, which in turn tilts upward the outer end of the clavicle, with the result that its shadow comes to lie across the apical field. Furthermore, the anatomical landmarks about the apex are disturbed, thus adding to the difficulty in correlating the physical with the roentgen-ray findings.

The accompanying illustration shows the patient in the position selected by us for increasing the visibility of the apical fields. The head is centrally placed, chin flexed, upper part of the chest in contact with the plate, shoulders lowered, the hands, with thumbs posterior, grasping the upper and outer part of the thighs, and the elbows rotated forward until they touch the table. Forward rotation of the elbows draws the scapulae outward so that their shadows lie outside the lung field. The patient in this position is directed not to raise the shoulders during the inspiration preparatory to the

*Read before the Saranac Lake Medical Society, November 24, 1920.

roentgen-ray exposure. Elevation of the shoulders is a natural but not necessary accompaniment of inspiration and will result in tilting the clavicles upward. The inspiration should be of moderate but not full depth, since the fuller the inspiration, the more the first rib tends to the horizontal, thereby diminishing the size of the apical field.

The accompanying roentgenograms of the same individual illustrate the position of the clavicular shadow in relation to the apical field with shoulders in the elevated and lowered positions.

With these points in mind, it has been possible for us to remove the clavicular shadow from the apical field in all but a few cases where it has not proven feasible because of anatomical peculiarities of the shoulder girdle.

FIG. 1.

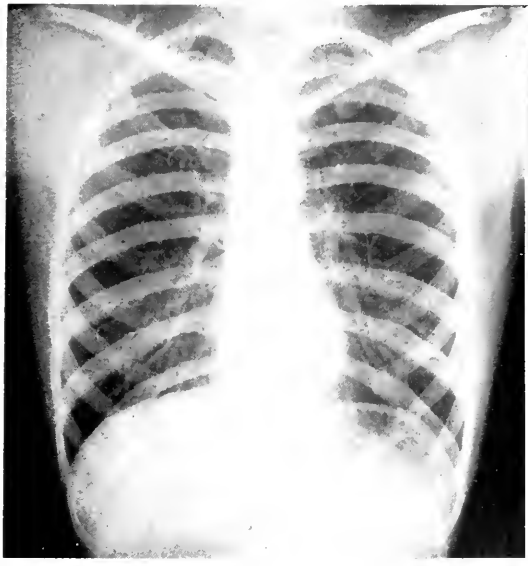

FIG. 2. Shoulders elevated. Clavicular shadow across the apical field, rendering difficult the interpretation of the lung markings in this region. Note the disturbance of anatomical relations, especially that of the outer end of the clavicle to the apical field.

Note: The relative position of roentgen-ray tube to patient and plate was identical for both exposures (Figs. 2 and 3).

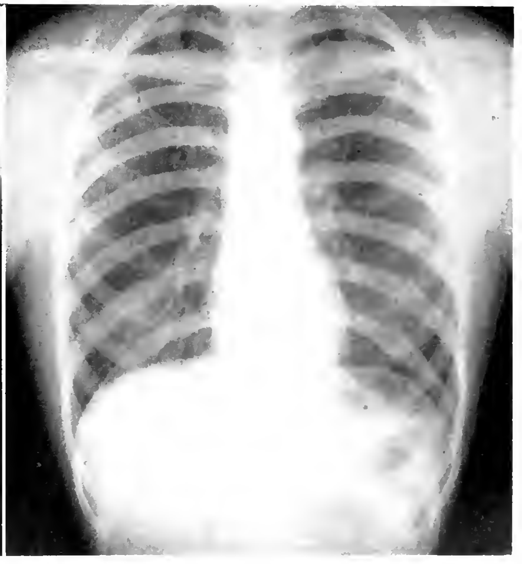

FIG. 3. Shoulders lowered. Clavicular shadow horizontal and visibility of the apical field increased. The normal position of the anatomical landmarks about the apex is approximately maintained, thus facilitating the comparative study of physical and x-ray findings.

A HISTOLOGICAL STUDY OF THE EFFECTS OF RADIUM ON CARCINOMA OF THE CERVIX*

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AND

NORMAN S. ROTHSCHILD, M.D.

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IN dealing with the treatment of cancer of the cervix by radium, let us consider first the clinical and pathological classifications. Ewing[1] has divided the condition into three stages: (1) A hard nodule in the substance of the cervical lip; (2) a circumscribed indurated ulcer of the portio or cervical canal, and (3) a non-diffuse low papillary outgrowth, covering a portion of the lip or canal. This classification holds true for the early cases of carcinoma of the cervix, which, however, unfortunately are rarely seen. He states that as usually observed the lesion is more advanced and exhibits first, an extensive induration and swelling of the cervix; second,an excavated ulcer, and third, extensive papillary or cauliflower outgrowths covering much of the canal and portio. Cullen[2] also classifies the condition into three stages: (1) Induration with loss of tissue; (2) disintegration, and (3) excavation. Another clinical classification is all important in the judgment of the treatment to be followed, and this classification is universally accepted by gynecologists using radium, the condition being considered, 1st, advanced, 2nd, borderline,and 3rd, early.

In the advanced and the borderline cases radium is effective in arresting the process, because of the fact that the pain is relieved, and bleeding and the foul discharges are stopped or considerably diminished. The improvement, however, takes place slowly, and discharge may be slightly increased the first week after the exposure. Further applications of radium may be required.

1. *Pathologically*, two types are found: (1) The squamous cell carcinoma of two varieties, basal cell and prickle cell, and (2) adenocarcinoma. Ewing has added the following atypical form: (1) Scirrhous carcinoma, (2) cystadenoma, (3) endothelioma, and (4) perithelioma.

Alter[3] has shown that the alveoli of basal-cell carcinoma in further proliferation take differing characteristic forms, so that in stages that are not too advanced it is easy to distinguish the following types: (1) Adenoid type, (2) solid type, and (3) cystic type.

Many factors are concerned in the effectiveness of radium on the malignant growth. Some cells may be radio-receptive, others radio-refractory. Colwell and Russ[4] have termed this selective absorption, while Dominici[5] has called it receptivity or sensitiveness. This idiosyncracy of the cells toward the rays depends first, on the life cycle of the cell. During mitosis it is more sensitive than in the resting stage. Mottram[6] has shown that the ascaris ova in mitosis are about eight times more sensitive than the resting cells.

2. *The Age of the Cells.* Immature, undifferentiated and embryonal cells possess a great affinity for radium, while mature cells and tissue have but a slight affinity. Embryonal cells as ova, spermatozoa and lymphoid cells are destroyed by the dosage of radium that would produce but slight reaction in the surrounding mature tissue. And the same has been observed in that the tissues of a child are more easily altered than those of an adult.

3. *Morphology and Function of the Cells.* Bergonis and Tirbondeau[7] believe cells vary in their reaction as they are definitely fixed or not in their morphology and function; for example, a neuroma is not very sensitive but is much more so than normal nerve. Testicu-

*Read by title at the meeting of the AMERICAN ROENTGEN RAY SOCIETY, Boston, June 15, 1921.

FIG. 1.

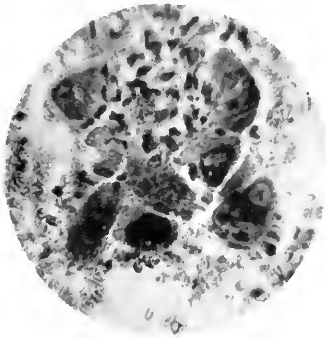

FIG. 2.

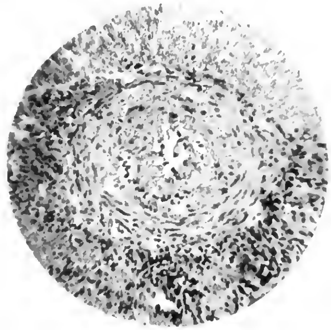

FIG. 3.

FIG. 1. High power. Section of squamous cell carcinoma, forty-eight hours after radiumization, showing edematous condition of the malignant stroma.

FIG. 2. High power. Showing malignant cells twelve days after radiumization with considerable increase in size. The nuclei show cessation of mitosis. The increase is noticeable in the size of the nuclei and the cytoplasmic substance.

FIG. 3. High power. The blood-vessels twelve days after radiumization, showing edema of all the coats, especially of the intima, with narrowing of the lumen.

lar island cells and spermatozoa are much less sensitive than the cellular layers they were developed from, and highly specialized cells like nerves, muscles, bone and cartilage, and red blood cells, all have a low radio-sensibility.

Wetterer[8] believes that the kind of cell damage is similar for all cells; it only differs in degree, varying as the quantity of absorbed rays, and as the specific radio-sensibility of the cell in question.

Let us note the various effects of radium rays upon normal tissue. The changes depend upon the length of the exposure and the infiltration of the rays. According to Knox,[9] slight exposure acts as a stimulant to the tissue, producing a congestion of the areas exposed, followed by an increased formation of fibrous tissue. If this exposure is prolonged or the infiltration insufficient, the action of the rays becomes a caustic one and an acute inflammatory process is set up,

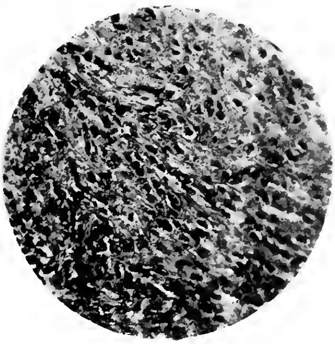

FIG. 4.

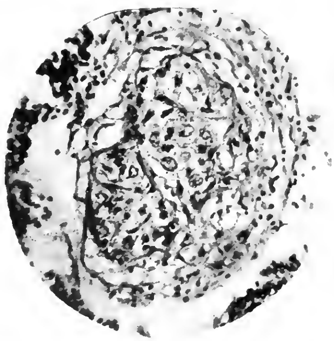

FIG. 5.

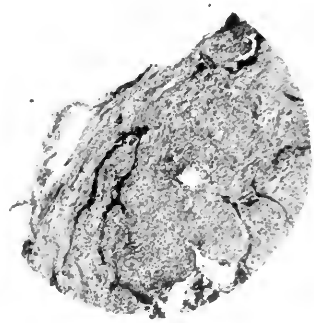

FIG. 6.

FIG. 4. Low power. Seven weeks after radiumization, showing fibroblasts infiltrating the malignant stroma and separating the malignant cells. The malignant cells are small in size and show evidence of destruction.

FIG. 5. High power. Eight weeks after radiumization, showing groups of malignant cells completely surrounded by fibroblasts. The malignant cells show destruction of the nuclei and vacuolization of the cytoplasm.

FIG. 6. Low power. Twelve weeks after radiumization, showing masses of chromatin in the fibrous connective tissue, the chromatin being the remains of the malignant cells.

which may go on to necrosis and sloughing of the tissue exposed.

When the exposure has been accurately calculated, the inflammation slowly subsides, the deeper tissues participating in the reaction of a diminishing ratio, according to their depth from the surface. There is in all the tissues an inflammatory condition, with a leucocytic migration and an invasion of small round cells. When this subsides, a fibrous tissue formation begins, and the newly formed connective tissue, with its capillary blood-vessels, may surround individual cells or areas of cells. By subsequent contraction of the connective tissue, the blood supply to these areas is diminished. Changes of a varying degree, according to the rate at which the blood supply is restricted, will occur. If rapid occlusion of the blood-vessels takes place, local necrosis will quickly follow. If it is more gradual, atrophic changes may ensue. When a section from the tissues is examined, all these changes may be found taking place at the same time in various parts of the section.

From the foregoing, two points may be emphasized: First, that after the acute inflammatory process subsides, there is a production of new connective tissue, which isolates individual cells or groups of cells; and second, by the contraction of this fibrous tissue we have occlusion of the blood-vessels and the cutting off of the blood supply to the isolated cells.

The histological effects of radium upon malignant tissue may be considered destructive and productive. By productive we mean the effects of the rays will produce tissue or cells which are not conspicuous in the histology of carcinoma or which appear in greater forces after the exposure.

We have divided the histological pictures into five stages.

1. *Stage of Acute Inflammatory Reaction.* This period embraces the first week after radiation and shows a congestion of the blood-vessels, exudation of lymphocytes and polymorphonuclear leucocytes, and a slight edema of the stroma. A slight swelling of the cancer cells is noted, also slight enlargement of the endothelium of the blood-vessels.

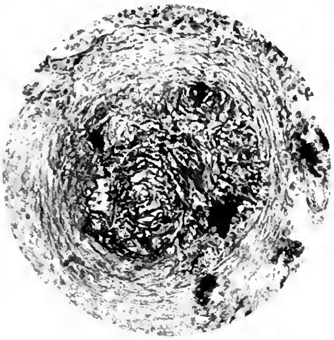

Fig. 7.

Fig. 8.

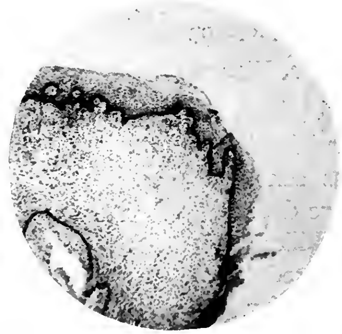

Fig. 9.

Fig. 7. Low power. The blood-vessels twelve weeks after radiumization, showing fibrosis of the intima and all the coats, with obliteration of the lumen.

Fig. 8. Fourteen weeks after radiumization showing complete destruction of the malignant cells in the fibrous field

Fig. 9. Low power. Sixteen weeks after radiumization, showing regeneration of the surface epithelium.

2. *Stage of Early Nuclear and Cytoplasmic Changes.* The second period embraces the second week and shows a gradual swelling of the cancer cells, an enlargement of the nuclei and relative increase of the cytoplasm. Mitosis in many instances ceases and the nuclear substance appears as granules. The cytoplasm, at times, shows vacuolization.

3. *Stage of Intercellular Changes.* At the beginning of the third week young fibroblasts are found scattered throughout the

radiated area. They infiltrate the malignant cells, dividing them into strands and in many instances completely surrounding groups of cancer cells and isolating them. The lymphocytic infiltration is increased in this stage, although lymphocytes and leucocytes have been present during the first two periods. The blood-vessels show edema of all the coats and especially of the intima, with almost complete obliteration of the lumen. At times leucocytes are present in the vessel wall.

4. *Stage of Destruction.* This period starts with the fourth week after the application of radium and continues to the ninth week. The nuclei of the malignant cells may be broken up and in many instances found as masses of chromatin, while, on the other hand, they may shrink and appear as an egg in a nest. The cytoplasm undergoes cytolysis. The group of cancer cells which have been isolated by the fibroblasts and connective tissue show a numerical reduction. The fibrous overgrowth at the end of this period is conspicuous. In its meshes the young blood-vessels at times show constriction of their lumen. The malignant cells throughout the entire field are considerably reduced numerically and in size.

5. *Stage of Healing.* In this final period the cancer cells appear as compressed bands in the fibrous stroma, only the small contracted nuclei remaining. At a later period no remains of the malignant cells are noted. Ultimately the surface epithelium shows regeneration.

The features of these changes are the changes of the malignant cells with their destruction and ultimate absorption and the replacement by fibrous tissue.

While the histological pictures have been divided into five stages, it must be acknowledged that the stages blend, and one may find many instances of early cellular changes with cells in the stage of destruction.

Caan[10] found the connective-tissue formation six to eight days after radiation when the malignant cells did not show any change. Finzi[11] believes the production of the connective tissue is the essential feature in the death of the malignant cell and destruction of the growth. Frank[12] believes that the rays cause the connective tissue to contract, with obliteration of the vessels and lymphatics and ultimate starvation of the malignant cells.

Ewing,[13] Schmitz,[14] Alter,[3] Wickham and Degrais,[15] and Dominici[16] have observed the cellular changes preceding the extensive fib--roblastic injection. We are of the opinion that the effect of the rays caused the cessation of mitosis, destruction of the nucleus, vacuolization of the cytoplasm and ultimate death of the malignant cells.

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A SIMPLE DRYING RACK FOR FILMS

By AMIN BOUTROS, M.D.

Roentgenologist to the Medical and Surgical Group of Denver

DENVER, COLORADO

WITH the transition from plates to films many of us were put to it to discover suitable substitutes for some of the conveniences of plate handling that were acquired by years of acquaintance with the plate. For example, I for one missed the plate drying rack, or rather, its substitute, and it was months before I hit upon a plan (now in use a year) that has so far proved quite satisfactory. At this late date it may prove of value to those who are still contriving drying devices.

It consists of a single dressed piece of 1¼ by 3 inch lumber. Three-sixteenth inch holes are drilled in its entire length, 2 inches apart and at an angle of 15 to 20 degrees, so that the holders are readily "hooked" in the holes of the rack as in Figure 1. The rack may be made any length desired and fastened over a sink or wash-tank or whatever other means are used to catch the drippings from the film.

In much the same way perpendicular holes can be drilled in a cabinet to store the holders while not in use, with the advantage of picking them out one by one without the loss of time caused by disentangling half the holders in your possession (Fig. 2).

Fig. 1.

Fig. 2.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

THE ANNUAL MEETING

The twenty-second annual meeting held in Washington the last week in September was in many respects the most successful in the history of the Society. The program included a full consideration of the most advanced problems before the *x*-ray world. With more than eight hundred registering, the sessions were always fully attended during the four solid days of program. The keynote of the meeting was "Deep Therapy," particularly as applied to carcinoma.

In a symposium on this subject, several of our foreign guests, Dr. René Ledoux-Le-Bard of Paris, Dr. Friedrich Dessauer and Dr. Hans Holfelder, both of Frankfort, presented in detail the underlying principles and they were supplemented by Dr. Samuel Stern, Dr. Wm. H. Stewart and Dr. Henry Schmitz, all of whom have made recent trips abroad and reported results. Although of necessity this symposium introduced highly technical problems, they were handled in as simple a manner as possible and were easily grasped by the listeners.

Scarcely less in interest was the symposium on therapy of the thyroid gland which embraced the toxic forms of goiter and carcinoma. This was presented by Drs. Geo. W. Holmes, A. F. Tyler, R. G. Allison, and G. E. Pfahler. Other therapeutic topics were therapy in skin diseases, which was discussed by Dr. H. H. Hazen of Washington, superficial malignancies by Dr. C. F. Bowen, interstitial radiation by Dr. Douglas Quick, brain tumors by Dr. H. C. Pancoast, diphtheria carriers by Dr. P. M. Hickey, and epithelioma of the cornea by Dr. D. Y. Keith.

The papers of Dr. W. D. Coolidge, Prof. J. S. Shearer, A. W. Erskine and Dr. Chas. L. Martin all consisted of scientific or experimental data which had a direct bearing on the basic factors in therapy.

Although much time was thus spent on therapeutic subjects, there was no lack of interest in the bountiful program devoted to diagnosis.

In the gastro-intestinal field, Dr. R. Walter Mills reported valuable observations on the small intestine; Dr. R. D. Carman discussed benign and malignant gastric ulcers; Dr. Jas. T. Case gave some collective results in pneumoperitoneum; Dr. L. G. Cole spoke on the differential diagnosis of certain duodenal bands, and Dr. A. H. Pirie showed how failures to cure by gastro-enterostomy could be sometimes turned into success after *x*-ray study.

Points on the diagnosis of sinus disease were brought out in the papers of Drs. G. E. Pfahler and J. G. Van Zwaluwenburg. Studies in pyelography were presented by Drs. Fred M. Hodges and W. L. Lim. Dr. Chas. M. Bowen and Dr. Willis Manges spoke on foreign bodies in the air passages, the latter limiting his remarks to the non-opaque bodies, for which he gave several new and valuable signs.

Topically unrelated, but interesting, were the papers by Dr. Myron D. Palmer who spoke on lesions of the spine, Dr. Edw. Blaine on Sprengel's deformity, Dr. Allen Scott Wolfe on dental radiography, Dr. H. M. Imboden on ossification of the meninges, and Dr. J. W. Pierson on pulmonary conditions in children.

A paper by R. B. Wilsey gave experi-

mental measurements as to the efficiency of the Bucky diaphragm principle. Among the new instruments presented were a new x-ray tube by Prof. T. E. Lilienfeld of Leipsig, a stereo-fluoroscope by Dr. J. D. Morgan, a simplified treatment unit by Dr. W. D. Witherbee, and a new oil-immersed unit by Dr. W. D. Coolidge.

In the executive sessions several changes were made in the constitution and by-laws, of which might be mentioned a clause requiring five years' practice in roentgenology before admission to membership, an increase in the annual dues, and an enlargement of the Executive Committee into an Executive Council. The Leonard prize was presented to Dr. A. J. Pacini and it was decided that it be offered again in the year 1923.

The guest of honor of the meeting was Dr. René Ledoux-LeBard of Paris, who delivered the Caldwell lecture. His address, "Progress of Deep Roentgen Therapy," was rendered in a pleasing and masterful manner and gave the members a valuable insight into foreign methods and results. Two of our other foreign guests, Drs. Dessauèr and Holfelder of Frankfort, gave the German viewpoint on the same subject and contributed materially toward the success of the symposium on deep therapy.

The annual banquet on Thursday evening was given in honor of Dr. Frederick J. Baetjer, one of our oldest members. President Christie, as toastmaster, introduced Dr. René Ledoux-LeBard of Paris, Dr. Wm. S. Thayer and Dr. J. M. T. Finney of Baltimore, Mr. Geoffrey Pearce of London, and Dr. P. M. Hickey of Detroit, who toasted and roasted our dear old "Baetch" to the point where he responded in kind and in plenty. After it was estimated he had gotten even with Dr. Finney he was presented with a beautiful book containing hundreds of appreciatory letters from members and friends.

The Society gave a rousing vote of thanks to Dr. Christie and the local Committee for their successful arrangements and kindly entertainment, which included many enjoyable trips for the ladies. In the closing session it was announced that the 1922 meeting would be held on the Pacific Coast.

Hollis Potter, Secretary.

A NEW PUBLICATION

Acta Radiologica is the latest periodical to appear in the radiological field. It is the official organ of the societies of Norway, Sweden, Denmark and Finland. Its articles are printed in French, German and English at the discretion of each writer, and it is edited by one of the foremost physicists and radiologists of the continent, Dr. Gösta Forssell. The editor visited the United States last year, and if one may judge the character of the Journal by its editor it will indeed occupy a lofty plane. Dr. Forssell has very kindly offered to send us abstracts of the articles appearing in the new Journal. Those of the first number appear in this issue. The American Journal of Roentgenology extends a most cordial welcome to the newcomer in this most interesting field and hopes that its days may be long and its sphere of usefulness great.

AN ANTHOLOGY OF MALIGNANCY

The careless individual pays little attention to the insidious condition until he finds himself the unfortunate possessor of

> A mass enormous! which in modern days
> No two of earth's degenerate sons could raise.

Pope: The Iliad of Homer, Book XX, Line 337.

> This, this is misery! The last, the worst
> That man can feel.

Pope: The Iliad of Homer, Book XX, Line 106.

The patient then seeks the advice of a physician and—

> Jove lifts the balances that show
> The fates of mortal men, and things below.

Pope: The Iliad of Homer, Book XX, Line 271.

The physician seeks a consultation with the roentgenologist who greets the patient thus:

> You go not till I set you up a glass
> Where you may see the inmost parts of you.

Shakespeare: Hamlet, Act III, Scene IV.

This examination seems to reveal certain findings and the patient exclaims—

O thou, whose certain eye forsees
The fixed events of fate's remote decrees.

Homer: The Odyssey, Book IV, Line 627.

But the patient is not satisfied with the careful analysis and honest opinion of his physician and consultants and seeks advice from charlatans. After futile treatment and chimerical promises he finds that all he receives from them is—

The windy satisfaction of the tongue.

Homer: The Odyssey, Book IV, Line 1092.

Swallowing his pride, the patient returns to the physician he can trust and places his case without reservation in his hands, declaring—

Let him, oraculous, the end, the way,
The turns of all thy future fate display.

Homer: The Odyssey, Book X, Line 642.

The surgeon proceeds to remove the major portion of the malignancy and—

So ends the bloody business of the day.

Homer: Odyssey, Book XII, Line 31.

And the patient is bettered in his morale for we find that—

Hope springs eternal in the human breast.

Pope: Essay on Man, Epistle I, Line 95.

But after a period of time the surgeon begins to despair as one—

Who lined himself with hope,
Eating the air on promise of supply.

Shakespeare: Henry IV, Part II, Act I, Scene 2.

For is it not often the case that—

The miserable have no other medicine
But only hope.

Shakespeare: Measure for Measure, Act II, Scene 4.

But the surgeon then has an original (?) and happy thought, for he turns the perfectly hopeless case over to the roentgenologist, but very fortunately for the latter—

Blessed is he who expects nothing, for he
Shall never be disappointed.

Pope: Letter to Gay, October 6, 1727.

And fortunately for the patient this radiologic creature of circumstance and opportunity creates a new interest in the patient and his appetite increases, for he realizes that—

He must eat to live and live to eat.

Fielding: The Miser, Act III, Scene 3.

And again we find that—

Hope like a gleaming taper's light,
  Adorns and cheers our way;
And still, as darker grows the night,
  Emits a brighter ray.

Goldsmith: The Captivity, Act II.

And the patient finds that—

Appetite comes with the eating, says Augeston.

Rabelais: Works, Book I, Chapter V.

The radiologist earnestly at work discovers that—

It is not strength, but art, obtains the prize,
And to the swift is less than to the wise,
'Tis more by art than force of numerous strokes.

Pope: The Iliad of Homer, Book XXIII, Line 383.

But the day surely arrives when the radiologist is forced to admit that—

What cannot be cured must be endured.

Rabelais: Book V, Chapter XV.

And the patient—

All, soon or late, are doom'd that path to tread.

Homer: The Odyssey, Book XII, Line 31.

E. H. Skinner.

CORRESPONDENCE

To the Editor:

Dear Sir: I have read with a good deal of interest the article in your Journal recently by Dr. Pfahler with reference to his modified technique of the Erlangen method of roentgenotherapy. It was my privilege last year to visit this Clinic, as well as a number of others on the Continent, and I was impressed with the severity of the roentgen sickness that seemed the inevitable sequela of the treatment.

Since returning home I have been endeavoring to the best of my ability to mimic their methods, and there is one feature that I regard as being worthy of note, and that is the object of this letter.

In the constructing of this Department, it was bulit as a wooden addition to the Hospital. The building is set on posts, and at my request these posts were tarred, then a false floor laid, on the top of which was a two

and one-half inch layer of asphalt. The asphalt was made on the ground, as I insisted. I stood by to be sure that all the sand that went into it was practically burned before being incorporated with the tar to avoid as much as possible any moisture. On top of this asphalt layer there is an air space of two inches, then the ordinary wooden floor covered with battleship linoleum. In this way I think you will agree that the operator as well as the patient is pretty well insulated; in fact he is actually "off the world." The patient, of course, is on a wooden table.

Now, in spite of the fact that we have been giving intense treatments—some ranging three hours in duration with the full capacity of our apparatus (which I estimate to be 9¾ inches), using copper filtration, yet we have been fortunate in that roentgen sickness has not been present following this treatment in any case.

The argument that naturally occurs to one here is that we have not been giving the heavy treatment. In answer to this I would say that in the other Hospital (St. Joseph's) I have been giving treatments really less intense, and the radiation sickness has been extremely annoying.

I am bringing this forward hoping that it will evoke some comment or criticism, and in the hope that it is a means toward relieving this distressing condition.

L. K. Poyntz.

ON THE ELECTRICAL DANGERS IN X-RAY LABORATORY

To the Editor:

Dear Sir: Although not a physician, nor a roentgenologist, I regularly read The American Journal of Roentgenology, and thereby increase my knowledge of that useful adjunct to the surgical and medical world.

My interest in such matters comes through the fact that for many years I have sold, installed and demonstrated to purchasing physicians, the use of modern, high-powered radiographic apparatus. I have visited the factories where such apparatus is made and have read all the articles on the subject which come to my notice.

In this way I read the article in your September, 1920, number entitled "Electrical Dangers in *X*-ray Laboratories" by J. S. Shearer, B. S., Ph.D., and I must confess to so strong a difference of opinion on one part of his article that I cannot refrain from addressing you in the hope that if I am wrong, you will show me just where. Naturally, it seems gross presumption for me to even suggest that such an eminent man as the author of that article could be wrong; nevertheless, though I have no titles to follow my name, I make so bold as to do so.

On p. 435, near the bottom of the second column, I read: "*But when placed on a grounded conducting table, danger is greatly increased,* quite contrary to traditional belief." (The italics are his own.) He goes on: "The path of least resistance from either terminal to earth is *from the terminal to the body*, thence to the metal table." (*These* italics are mine.) This statement surely is incorrect, for the following reason. The path of least resistance from either terminal to earth (if the tube stand is grounded, or the table, in the case of an attached tube stand) is from the terminal to the *nearest metal part of the tube stand*. There isn't a metal table on the market which would not have metal parts of the tube carriage nearer, by far, to the terminals of the tube, than *any part* of the patient's body would ever be. Therefore the path of least resistance, as I have said, would be from the terminal of the tube to the metal of the tube stand carriage.

It would of course be possible, by a very careless misadjustment of the tube above the patient, to cause one of the terminals to come closer to the patient than any of the metal parts of the tube stand, but I am not allowing such a supposition as that to be entertained, any more than I would brand street cars on our public streets as extremely dangerous simply because if one deliberately places himself in front of one of them while in motion, he will be killed!

Nor would there be any way to prevent a serious shock to a patient being radio-

graphed if he was timid, or nervous, or a child, or feeble minded, etc., as the author pointed out on page 437 and due preventatives were not used. When radiographing any such patients, the precautions mentioned in the article should be taken.

Therefore I am barring those two possibilities of danger from my treatment of the subject, since they properly are barred. I also am confining my statements to the assumptions that metal tables only are referred to, as they are in the part quoted. Any metals used in the construction of a table and its tube stand will be *far better* conductors than the human body. And since no radiograph would be made by an operator, who knew the first thing about his work, with one terminal of the tube pointed down close to the patient, *some metal part* of the tube carriage will *always* be nearer to the tube terminal than the body of the patient can be. How then does the rule of least resistance, quoted by the author, cause the current to seek the earth through the excellent airgap of insulation, the high resistance of the patient's body, and the metal of the table (which is grounded) *rather than* jump *directly* to that grounded metal which is *far nearer* to the tube terminal?

The next statement to which I take exception is in the sentence following that already quoted—"since the tube terminals are insulated from the stand in all cases." In other words, the current will find it easier to jump from ten to fifteen or more inches directly from the tube terminal to the patient's body, with the latter's high resistance added, and thence to the ground through the metal of the table, than to jump from *five to six inches* to the nearest part of the metal of the tube carriage, *which by the way*, is always *right in the very path* of a jump between the tube terminal and the patient. Why should the current deliberately overlook such a good ground as the grounded metal of the tube stand in its *bigger* jump to the patient through the air, which is one of the best insulators there is, when dry. So I would say that not only are the tube terminals insulated, as in the above quotation, but the *patient is as well,* through the large air gap separating the patient and the tube terminal.

My belief is that given a metal tube stand attached to a metal table, it is far safer to work with the table grounded than not grounded, which is exactly the opposite to the conclusions of Dr. Shearer; but I trust I have shown sufficient reasoning to give my contradiction the weight it must have to stand against such an authority as I am respectfully but none the less positively differing with.

As this is an extremely important question (the grounding or not grounding of radiographic metal tables having tube stands as an integral part) and as there are many workers using grounded tables, which, if more dangerous, should be warned to change, I would very much indeed be gratified to see this subject discussed again in the columns of your Journal. I feel that many practical workers and electricians will not agree with the author of the article referred to, and I hope you will *care to secure some other authorities to write on the subject.* It is not only interesting as an electrical and radiographic problem, but has the merit, if once and for all settled, of saving the lives of patients.

J. T. Warner.

To the Editor:

Dear Sir: We have read with great interest the article by J. S. Shearer, B. S., Ph.D., on the electrical dangers in the *x*-ray laboratory, in the September issue of The American Journal of Roentgenology and are gratified to see the comment at the end of his article in which he refers to the leaflet published by us some time ago.

Evidently this leaflet is of some interest to the workers in your country, and we are pleased to note that most of the warnings which we issued, all of which apply in this country, apply in yours also.

We note that your contributor takes exception to one or two of the suggestions put forward, but we feel that perhaps he has

not quite appreciated our intention, or the possibility of different conditions prevailing in the two countries. In warning No. 3 it will be found we distinctly state that insulated wire should be treated with the same precaution as bare wire, which is contrary to encouraging any feeling of false security.

With regard to clause 5, we are in entire agreement with Mr. Shearer that tubing is far better for high tension overhead wires, but our warning was issued to the great many private installations and hospitals that have been installed for a number of years, and who are not prepared to scrap their present wiring and go to the expense of installing an overhead tubing system. No doubt in the course of time all installations will be fitted up with tubing to carry the high tension current. It was for the reason that we knew many of these installations had been up in use for a long time without attention that led us to add the extra precaution of grounded wires beneath the overhead cables, and most apparatus in this country is already fully protected against short circuitings which might occur if no special precautions were taken.

So far as paragraph 7 is concerned, we would like to point out that all our machines are already provided with circuit breakers, but we presume that the American machines are not so provided, and we feel that in spite of the vagaries of fuses, it is better to insert a fuse that is rated to blow at a definite current, rather than to have no fuse at all in the circuit. It is possible now to get a close guarantee with certain cartridge fuses; this practically eliminates the old trouble of fuse wire which can be considerably overloaded for disruption.

In reference to paragraph 8, this naturally applies equally well to all high vacuum tubes in the same way that it does to the Coolidge tube, the Coolidge tube only being mentioned as a well known example.

Geoffrey Pearce.

To the Editors

Dear Sir: Were it not for the prevalence of some unfortunate ideas relative to rendering *x*-ray apparatus safe by grounding, the writer would hardly care to add to the previous discussion. However, where such misunderstandings exist, every effort should be made to clear matters up.

The letter of Mr. Geoffrey Pearce comes as a very pleasant reminder of a brief visit with him in London where some matters of mutual interest were discussed. I am quite sure he will agree that in any installation where a revision of high tension wiring and replacement by tubing would increase safety, the cost ought to be regarded as an insurance. Such systems may be made effective and yet be very inexpensive.

The matter of circuit breakers and fuses should be simple; we had better use *both.* Fuses have been in common use on American machines for years, but up to 1915 the writer does not recall seeing quick acting circuit breakers on standard *x*-ray machines. Since that time several makers have added them.

Mr. Warner's letter seems to show a little irritation; that, as is often observed, does not contribute to rational consideration of the subject.

The fourth paragraph of his letter raises a question of fact that may be easily disposed of by a little consideration. Mr. Warner states: "There isn't a metal table on the market which would not have metal parts of the tube carriage nearer, by far, to the terminals of the tube than *any part of the patient's body would ever be.*" The first answer to this statement is the simple record of death in the use of just the apparatus he mentions. The second is to consider actual stands and conditions as observed in practice. Measurements of the distance from tube terminals to the nearest metal of the stand show distances varying from 5 to 9 inches. Observation in hospitals and offices shows many cases where the tube terminals or live wires are nearer the patient than this. In kidney and ureter examinations with catheters in place, the distance to the elevated knees may be only a few inches; in dental work on a lower jaw the writer has observed operation at distances less than 5 inches on

several occasions. It is quite common to read of treatment at a 7 inch or an 8 inch target skin distance and the metal terminals will usually be as close to the patient as the target and may often be nearer. Experience has shown that one can not predict with certainty the path that will be selected by a sudden rush of current, but it does not tend to maintain a flow to insulators or to any extent to conductors when these are so well insulated that *no discharge path is provided*.

Paragraphs 7 and 8 are based on assumptions largely erroneous. The resistance of the human body does not count for much when we are dealing with the high voltages in use on *x*-ray tubes.

The resistance of the body may be as low as 5,000 ohms. If half the voltage used to operate a tube at a 5 inch gap is applied to the body and maintained, the current would be nearly 6 amperes. Cases are on record where contact with a circuit of less than 100 volts has caused death, although the current must have been less than 1/50 of an ampere.

Just how a patient on a grounded table in proximity to a high tension line from a transformer with a grounded point on its secondary, can be regarded as insulated, I am quite unable to understand.

We may have the body of a patient fully insulated from all portions of a high tension circuit or we may have *one* contact with such a circuit. The latter is the case when the patient is on a grounded metal table and the center of the secondary is grounded. Surely the maximum safety is secured when insulation of the patient is made as complete as possible. The only question to answer is, would the patient's safety be *increased* or *decreased* by the use of a grounded metal table as compared with the use of one well insulated or one made entirely of insulating material?

One should not discuss this matter on a basis of no unusual conditions or on the assumption that all operators are exceedingly careful at all times or that patients never move during an examination. The chance of too close proximity to the tube terminals or

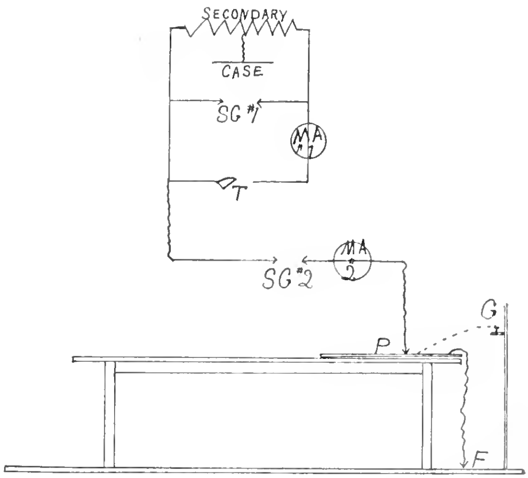


FIG. 1. S.G. No. 1. Spark gap on main circuit.
S.G. No. 2. Spark gap in series with M.A. No. 2.
M.A. No. 1. Measures tube current.
M.A. No. 2. Measures current to P.
F. Floor
G. Water pipe
P. Metal plate or pail of water.
The current through spark gap No. 2 flows from the outer end of one half of the secondary winding through the gap to the floor or ground, back to the case and thence to the inner end of the half of the secondary. High insulation between P and the floor or earth will effectually prevent such flow.

line is the *same* whether one is on an insulated table or on a grounded conducting table. The question reduces to simply this, *what are the relative chances of escaping serious injury in the two cases* if something unusual happens or when someone is closer than is intended?

No one informed on the subject is likely to deny that the larger the current maintained through the body for a given time the more serious are the results likely to be. We may easily test for the amount of current without using a patient.

A small metal plate or a pail of water may be placed on a dry wooden table and a spark gap and a milliammeter connected in series to one terminal of the tube. The plate or the water may then be regarded as related to the circuit in the same manner as the patient's body. When no connection is made from the conductor to the earth we have the case of a well-insulated patient. When a wire passes from the conductor to the floor we have a

partial ground. When the wire is connected to a water pipe we have a complete ground.

Figure 1 shows the arrangement of apparatus and Figures 2 to 5 are photographs of the set-up, showing some of the meter readings and the nature of the discharge.

The tube was excited by a transformer of standard make with the usual connection between the middle of the secondary and the case, but the case was not grounded by a conductor, it simply stood on a dry wooden platform. Under these circumstances there would be less current than when the case is well grounded. Spark gap No. 2 and milliammeter No. 2 serve to show how close a conductor must be brought to the line to get a discharge and the milliammeter shows what current flows when a discharge occurs.

Three conditions are considered:

(1) When the plate P is insulated.

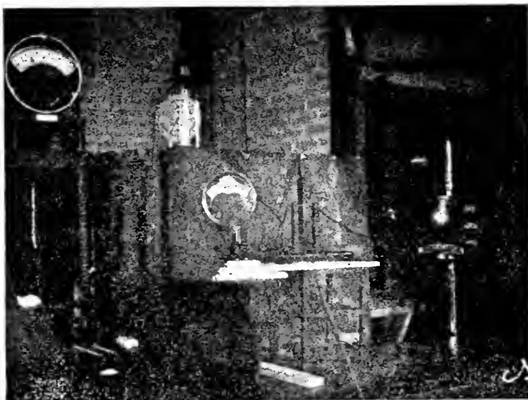
(2) When a poor or partial ground is made by a wire to the floor. (In this case the wooden floor was laid on concrete.)

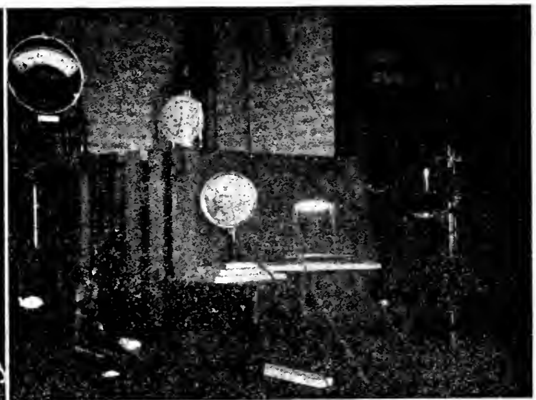
(3) When grounded by a piece of wire to a water pipe.

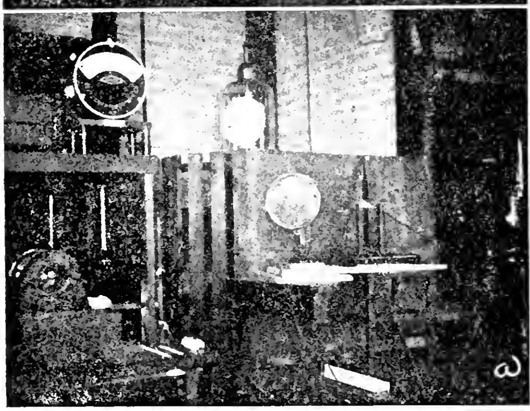
Not only were readings taken of the gaps and the currents passing, but flash light photographs were used to get instantaneous readings of the meters. A large electrostatic voltmeter in the background gave the high tension line voltage.

In each case, with no metal connection to the floor or pipe, there was no appreciable current to the plate even on direct contact, i.e., when spark gap No. 2 was closed.

Figure 6 shows the photographs of spark gap No. 2 with the data of tube operation at the time the discharge occurred. A scale







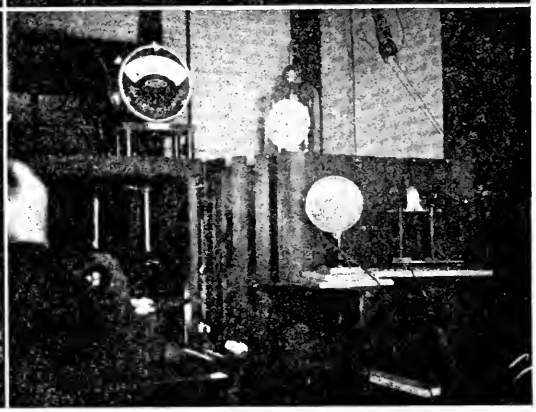


FIG. 2. 5 ma.; 8 inch spark gap; well insulated. Slight leakage across gap No. 2; too weak to photograph; not enough to deflect the milliampere needle.

FIG. 3. 3 ma.; 8 inch gap; resistance control; partial ground; spark discharge.

FIG. 4. 4 ma.; 5 inch gap; resistance control; partial ground.

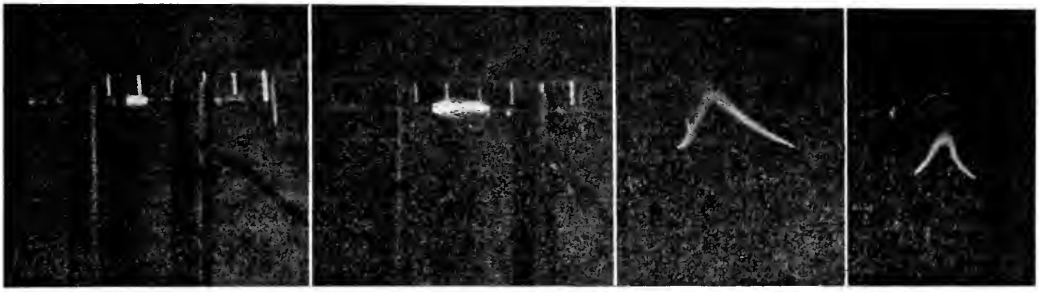
FIG. 5. 5 ma.; 3 inch gap; auto-transformer control; complete ground; gap current exceeding 200 ma.

in inches placed just back of the gap was photographed at the same time and indicates the jumping distance from one terminal of the tube to the conductor under normal conditions of operation.

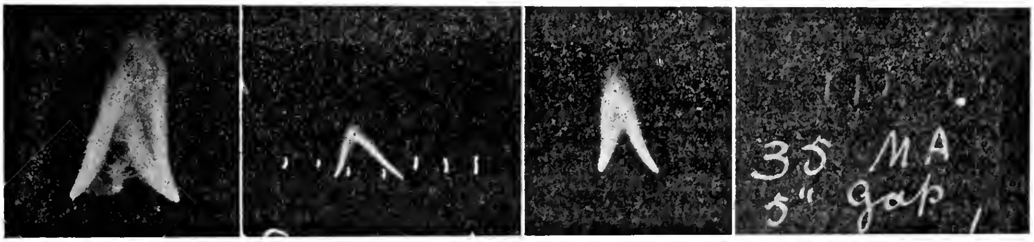
It should be remembered, however, that any irregularity of operation or especially the opening or failure of the filament circuit, either a partially grounded or a fully grounded conducting support.

The Table gives a few of the readings and conditions of operation.

When trying the same tests, using a transformer without a grounded middle on a setting of 5 ma. and a 9 inch gap, the passage of a spark through 2 caused a break of 14



No. 1. No. 2. No. 3. No. 4.



No. 5. No. 6. No. 7. No. 8.

Fig. 6. Photographs of discharge across gap No. 2 under various conditions. Observe the insignificant spark discharge when plate is insulated. The most serious arc was on a setting for 5 ma., an 8 inch spark gap with an auto-transformer control.

No. 1. 5 ma.; 5 inch gap; resistance control; no ground. A series of sparks; current too small to measure.
No. 2. 5 ma.; 8 inch gap; resistance control; insulated. A series of sparks; current about 12 ma.
No. 3. 5 ma.; 8 inch gap; resistance control; grounded; current about 25 ma.
No. 4. 5 ma.; 8 inch gap; auto-transformer control; partial ground.
No. 5. 5 ma.; 8 inch gap; auto-transformer control; current more than 200 ma.
No. 6. 35 ma.; 5 inch gap; grounded; resistance control.
No. 7. 35 ma.; 5 inch gap; grounded; auto-transformer control.
No. 8. 35 ma.; 5 inch gap; insulated; resistance control.

or a cranky gas tube bringing surges into the line, would greatly increase this sparking distance and it may even exceed the full gap of the transformer at normal operation.

Figures 2 to 5 show some of the photographs by which readings were made. The actual current would vary somewhat according to the length of gap No. 2. When one realizes that only a few ma., often less than 50, may result fatally, it is quite clear that the insulated support is very much safer than inches from the other high tension line, followed by an arc to the synchronous motor and a burn-out. In this case had *one* side of the line become grounded to any stand or table, a distance of 14 inches would not have protected the patient from the *other* line.

Clearly there can be no question that the patient's safety is much greater when insulated as fully as possible.

We may then summarize as follows:

1. Under all conditions of operation the

danger of a discharge to a patient is much less when he is completely insulated than otherwise.

2. The current passing to a patient by a spark discharge, or even by contact with one terminal when the patient is well insulated, is too small to show on the usual milliammeter. Note that a slowly acquired charge may give no sensation and is not a source of danger; a path to and from the body must be provided to cause death or injury.

3. Danger of spark or arc to the patient is rather greater when a resistance is used than with an auto transformer. Danger of spark over is much greater on closing the circuit than when operating steadily, and any spark over may be followed by an arc.

4. The current on break over resulting in an arc is always greater with an auto transformer.

5. Therapy at high gap should always be done with a transformer requiring a large series resistance and not with one using an auto-transformer control.

Table

Tube Current MA.	*Working Gap or Voltage*	*Meter No. 2 MA.*	*Gap No. 2*	*Ground*	*Control*
25	4½″ gap	0	¼″	none	Res.
		70	3″	partial	Res.
		85	2″	partial	Res.
20	70 k.v.	40	4″	partial	Res.
20	80 k.v.	100	4½″	partial	A.T.
30	5″ gap	200+	1¾″	complete	A.T.
30	5″ gap	0	1½″	none	Res.
30	5″ gap	80	1½″	partial	A.T.
30	5″ gap	120	1½″	complete	
0	8″ gap	18	5″	complete	Res.

Res. Resistance control; A.T. Auto transformer control.

The last reading illustrates surge gap on sudden interruption of current. The filament current was cut out and a break over of 5 inches or 1 inch more than half the working gap resulted.

Observe also that when a body is well insulated the currents resulting from small sparks are not large enough to give a milliampere reading.

6. The small 10 to 30 ma. transformers using no resistance are about as dangerous as large ones with auto-transformer control.

7. The safest operation when the patient must be between table and tube is secured by good insulation of table, stand and operator. Also when this is done the troublesome slight leakage discharge is eliminated.

8. Dental chairs are grounded and hence are dangerous for x-ray work.

As good insulation of patient and operator is the only guarantee of safety, we should endeavor to secure such installations as fast as possible.

J. S. Shearer.

TRANSLATIONS & ABSTRACTS

PANNER, H. J. On the *X*-Ray Examination of Duodenal Ulcer. (*Acta Radiol.*, 1921, 1, No. 1.)

The author gives a detailed account of the direct and indirect roentgenological signs of ulcer of the duodenum.

In roentgenological examinations of the duodenum the patient may be placed not only in the upright position but also in the recumbent position (dorsal, ventral and lateral positions). Too much importance should not, however, be attached to the *indirect* symptoms. The *direct* symptoms, the *deformity* of the bulbar-shadow, and especially *Akerlund's type,* are the best characteristic signs for the radiological diagnosis, and these seldom prove a source of diagnostic error, but the technique necessary to *obtain* them demands great experience and much patience.

SIMON, M. On the *X*-Ray Diagnosis of Gall-stones in the Common Duct. (*Acta Radiol.*, 1921, 1, No. 1.)

Cases of gall-stone in the lower end of the common duct, roentgenologically not directly visible as a positive shadow, but as a defect in the barium-filled duodenum. In the prone position the stone made an impression in the intestinal wall immediately above Vater's papilla.

KLASON, T. Hemophilia and Hemophilic Arthropathy. (*Acta Radiol.*, 1921, 1, No. 1.)

References in Literature. The writer has himself observed three cases of hemophilic arthropathies showing different stages. As characteristic of their *x*-ray picture, he states: In the early stages a cloudiness of the capsule from blood-clots and later decalcification, alteration of the cartilages and deformities, producing a hypertrophic arthritis deformans.

The knees are the most affected of all the joints, and besides the above mentioned alterations in the capsule and cartilages there are deformities and enlargements of eminentia and fossa intercondyloidea as the result of hemorrhages into the attachments of ligamenta cruciata genu.

STRÖM, S. A Case of Arthropatia Psoriatica. (*Acta Radiol.*, 1921, 1, No. 1.)

A case of arthropatia psoriatica with advanced destructive and atrophic changes of bones and joints in fingers and toes. The case indicates the affinity of the affection with bony changes of a neurogenic nature.

JOHANSSON, S. A Case of Osteogenesis Imperfecta with Extended Arteriosclerotic Changes. (*Acta Radiol.*, 1921, 1, No. 1.)

The author describes a case of osteogenesis imperfecta with multiple fractures, which is of special interest, as distinct arteriosclerotic changes in the arteries of the upper as well as of the lower extremities are shown on the *x*-ray plates. Histological examinations showed degeneration and calcification of the intima and media of the arteries. Thyreoidea and thymus markedly small. No similar case has been described, so far as the author is aware of.

HANSSON, H. A Case of Fracture of the Cranium with Accumulation of Air in the Cranial Cavity. (*Acta Radiol.*, 1921, 1, No. 1.)

The author gives an account of the cases of so-called "pneumatocele cranii" in the early and modern literature, and describes a *traumatic cyst in the right frontal lobe of the brain,* observed and roentgenographically examined by him, and containing air and liquid, which occurred in consequence of a fracture in the coronal area, penetrating the frontal sinus. The patient recovered without surgical treatment.

FORSSELL, GÖSTA. A Plateholder for Precise Roentgenography in Connection with Fluoroscopy. (*Acta Radiol.*, 1921, 1, No. 1.)

The article describes a new construction for centering and fixation of small plates on the site of a limited screen image by vertical fluoroscopy. The fluoroscopic screen is supported by an iron holder, framing a thin wooden plate. Guides are placed both on the

right and the left side on the holder, and these are connected with each other by a thin, horizontal steel wire, kept tense by a spring and movable vertically on the guides. A wooden ball is movable on the wire laterally. When the image is limited for roentgenography by fluoroscopy, the ball is placed just in front of it, the screen is removed and a cassette of convenient size is put behind the ball, which presses the cassette against the wooden plate framed by the screenholder. By this arrangement it is possible to make sharply limited plates very speedily during the vertical fluoroscopy.

Heiberg, K. A., and Strandberg, Ove. Microscopic Examination of the Mucous Membrane of the Nose on Patients under Treatment for Lupus Vulgaris with Universal Arc-Light-Baths. (*Acta Radiol.*, 1921, I, No. 1.)

Under the treatment with the universal coal-arc-light-baths reparative changes take place in lupus vulgaris of the mucous membrane of the nose.

The manner in which healing is brought about under the treatment with light-baths, is histologically seen to be even qualitatively different from the picture one meets with in the feeble spontaneous attempts at healing of the lupus vulgaris of the mucous membrane of the nose. Moreover, these examinations have shown that the healing of the mucous membrane of the nose in lupus vulgaris, which can be clinically proved under the above-mentioned universal light-bath treatment, is not a merely apparent healing, but a real healing process, histologically proved.

Sievert, Rolf M. The Distribution of the Intensity of the Primary Gamma-Radiation in the Neighborhood of Medical Radium Preparations. (*Acta Radiol.*, 1921, I, No. 1.)

In consideration of the absorption and "dispersion," some formulas for the estimation of the gamma-ray intensity of the primary rays in various sources of radiation have been derived.

In order to utilize these formulas in radium therapy, some tables have been arranged. The relative intensities at different distances of a cylindrical radium preparation have been examined by means of an ionization method. The values observed correspond very well with the estimation. The secondary radiation of water has been measured after passage through about 1 mm. glass at a distance of .2 cm., and it was shown that this amounted to less than 2 per cent of the total intensity.

Dr. Lars Edling, lecturer in medical radiology in the University of Lund, in the first number of Acta Radiologica begins a richly illustrated article: *On Plastic Means of Application in Radium Therapy.*

Deep Radiotherapy and Its Realization with a French Apparatus. (*Arch. d'électric. méd.*, March, 1921, p. 69.)

(This is an unsigned article based upon information furnished by the Gaiffe-Gallot and Pilon Co., and by Dr. Dauvilliers of the Paris Laboratory of Physical Research.)

The apparatus described is one constructed by Gaiffe-Gallot and consists essentially of a Rochefort-Gaiffe coil feeding a tube immersed in oil contained within a completely closed lead box. It is well known that the coil furnishes a current of more constant voltage (at a low milliamperage) than does an interrupterless transformer and that with the same temperature in the anticathode a more homogeneous ray results. With the apparatus described, an equivalent spark-gap of 40 cm. measured between points, may be obtained, representing a voltage of about 200,000 volts. The inverse is suppressed by the introduction into the circuit of a kenotron. The tube carriage is swung from an overhead track, the high tension current being supplied by isolated vertical wires. The tube box proper is completely closed, filled with oil, and has lead walls 6 mm. thick. This thickness is sufficient to reduce the initial value of the rays 10^{-10}. The rays escape through an aluminum window in the bottom of the box. Perfect protection from the rays and from the high tension current is claimed for both the patient and the operator. There is no appreciable ozone production. The circuit may be opened or closed, even at the maximum spark-gap without risk to the tube.

Lowell S. Goin.

Japiot, P., and Bussy, L. Radiotherapy in Interstitial Keratitis. (*J. de radiol. et d'électrol.*, v, No. 3.)

In spite of the pessimism of the past, radium

therapy has a definite place in ophthalmology. In the hands of the writers the x-ray treatment of interstitial keratitis has yielded particularly good results. All forms of parenchymatous keratitis are not equally suitable for treatment, hereditary and specific forms yielding more readily than others. Better results are obtained in young than in older subjects. The writers' best results were obtained in children from seven to ten years of age. In a girl eighteen years old progress was much less rapid. Treatment must be instituted as early as possible. Early treatment may succeed in aborting the disease, or at least the cure will be more complete and accompanied by much less opacity of the cornea. One of the most remarkable effects of radiation is the relief from pain and the prompt disappearance of the blepharospasm and photophobia.

There are two dangers to be avoided in the treatment of this condition; first, the destructive action of the rays on the eye itself and particularly on the juvenile eye in the course of development; second, the destructive action of the rays on the appendages of the eye. The destructive effect of rays on the eye has been disputed, some affirming the possibility of serious accidents and others denying this possibility. It seems to be a fact that these accidents are improbable in adults, even with large doses. But though negligible in adults, there is a real danger of injury to the eyes of children, a fact which induced the writers to use very weak doses in the treatment of interstitial keratitis, since it is a disease of childhood. The danger to the ocular appendages is more serious. The loss of the eye lashes and the occurrence of scar tissue on the free borders of the lids constitute a serious injury. The writers therefore limited the field of radiation to the cornea by employing as protection a sheet of lead pierced by an orifice the diameter of the cornea. The technique is described rather vaguely as consisting of the employment of a hard tube, 3 mm. of aluminum filtration, and an exposure of five minutes. The milliamperage is not stated. The writers estimate the total dose delivered to the ocular globe as 1½ H., or about ¼ H. at each séance. Five séances at intervals of one week constitute a series. One series is usually sufficient. The usual forms of therapy should be continued during the treatment. Two cases are reported in detail.

L. S. G.

Warnekros. The Third Stage of Labor in Roentgenograms. (*Arch. f. Gynäk.*, 1918, cix, 266. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

To obtain accurate pictures of the placenta within the uterus it is necessary to inject immediately after the birth of the child, into the umbilical vein a sterilizable, opaque fluid. Warnekros found barium sulphate most useful. First blood is permitted to escape freely, so that rupture of placental vessels through overfilling is avoided. A short exposure of three to five-tenths of a second is sufficient. His observations permit the following deductions in regard to the mode and the time of detachment of the placenta: The placenta, as a rule, separates first at the edge, as always has been claimed by investigators in opposition to theorists. With but rare exceptions, the placenta reaches the internal os edgewise, and in this position glides into the vagina. Only in the vagina occurs the inversion which causes the placenta to appear outside the vulva exposing its fetal surface, or as customarily designated, in the Schultze mode. However, in a few pictures, the placenta was seen to detach first in its center, actually corresponding to the Schultze modus.

In accord with the more prevalent idea the separation of the placenta does not begin until the fetus is expelled from the uterus. Warnekros is forced to the conclusion that the detachment starts at the moment when the uterine muscle retracts over the escaping fetus, and is accomplished by the first few subsequent contractions, because in all his pictures, though taken within five minutes after the birth of the child, the placenta appeared completely detached. This was true even in forceps extractions, in which the general anesthesia probably had precluded strong contractions after the passage of the fetus.

Only in one instance could he photograph the placenta still in its normal attachment to the uterine wall. This was in a case of twins. Injection and exposure were finished before the second child had been born. The presence of the other fetus in the uterus, in his opinion, had prevented the retraction essential for the process of detachment.

This particular case, in his belief, also presents the strongest possible proof that the injection of fluid into the umbilical vein does not,

as has been claimed by some, actually cause the very quick separation of the placenta uniformly ascertained in his pictures.

Warnekros. Attitude and Mechanism of Expulsion in Breech Presentation. (*Arch. f. Gynäk.*, 1919, cx, 793. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

Splendid roentgen pictures, presented in this article, show that also in breech presentations the fetus maintains a comfortable attitude, and that during labor the expelling force of the uterine fundus is actually transmitted by the vertebral column to the presenting breech. In Warnekros' belief this finally disposes of all objections raised by certain writers who have refused to accept the theory of such a transmission in pelvic end presentations.

Weibel. Study of the Third Stage of Labor in Roentgenograms. (*Arch. f. Gynäk.*, 1919, cxi, 413. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

Out of forty-one attempts to photograph the placenta in the uterus, twenty-eight proved eminently successful. Weibel with some right claims priority over Warnekros in these studies of the third stage. The terms "Schultze" (more correctly Baudelocque) and "Duncan" mode of placental detachment must disappear from obstetric nomenclature. The actual mode of expulsion of the placenta from the vulva has no relation to the mechanism of its detachment. The opinion, still defended by some writers, that the separation begins during the stage of expulsion of the fetus, is untenable. In all normal labors, in which the final expulsion of the child is chiefly accomplished by abdominal pressure, the placenta is found in complete attachment at the moment of the expulsion. Detachment begins immediately afterwards, either at the edge or in the center, possibly in some instances simultaneously over its entire surface. In sliding down, the placental edge reaches the cervix first; occasionally this edge is seen bent over. The mode of its final appearance is dependent upon changes occurring during its passage through the vagina.

Warnekros. Spontaneous Change of Position of Full-Term Fetus During Labor. (*Arch. f. Gynäk.*, 1918, cviii, 475. *Am. J. Obst. & Gynec.*, 1920, i, 320.)

Two cases are represented in several roentgenograms, showing distinctly the spontaneous change of a breech presentation into normal head presentation in the course of the first stage of labor. This is the first graphic, and therefore unimpeachable proof for such a change of position which had been claimed as possible by clinical observations.

Vogt. Roentgenologic Proof of Extrauterine Life. (*Ztschr. f. Geburtsh. u. Gynäk.*, 1918, lxxx, 344. *Am. J. Obst. & Gynec.*, 1920, i, 320.)

This is a problem of great forensic importance. Efforts in this direction were first made by Vaillant. While in the living newborn, before he has received any nourishment, intestines and stomach are not visible in the *x*-ray picture, in the stillborn they are clearly visible. Similar investigations also had been made in regard to the lung pictures of stillborn and living newborn infants. Some investigators came to identical conclusions, others felt unable to concur in the findings. Vogt studied the problem on a very large material. He comes to the conclusion that the method is of some value if used critically, but is applicable only in cases in which no artificial resuscitation (especially swinging according to Schultze) had been attempted. The pictures must be taken very early before gases have formed as the result of beginning putrefaction. Otherwise grave errors cannot be avoided.

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A PRELIMINARY REPORT ON THE EFFECTS OF ROENTGEN RAYS ON GASTRIC HYPERACIDITY*

By LLOYD BRYAN, M.D., AND HUGH F. DORMODY, M.D.

Roentgen Department, Mt. Zion Hospital

SAN FRANCISCO, CALIFORNIA

IN Germany, Bruegel and Wilms have been using the roentgen ray with very promising results in cases of duodenal and gastric ulcer with hyperacidity. This is merely a preliminary report of work along similar lines which we have recently started. It is hoped to carry this investigation further during the next year.

The following cases are reported as typical results of the investigation thus far:

CASE F. 4025. Woman (P. P.). Age forty-five. History of past eight years typical of duodenal ulcer. This was confirmed by roentgen examination. Wassermann negative. Urine and blood normal.

GASTRIC ANALYSIS

Fractional Ewald Test Meals

3:15:21 Free	HCl	Total Acid	3:16:21 HCl	Total Acid	3:17:21 HCl	Total Acid
1st 15 min.	15	85	20	50	25	50
2nd "	15	90	25	70	.. not enough	..
3rd "	30	105	30	80	40	90
4th "	25	90	35	80	50	90
5th "	50	100	40	80	55	100
6th "	55	100	.... tube broken		55	85
7th "	65	105	65	100	85	95
8th "	70	100	50	110	85	100

Three test meals were taken on three successive days (i.e. as above), in order to establish as nearly as possible the exact nature of the gastric secretion.

During the entire period of patient's stay in the hospital, she was given a substantial appetizing diet consisting of cereals, eggs, cream soup, cooked vegetables, chicken, fish, all kinds of desserts, with tea, coffee and milk. No medication for relief of gastric symptoms was given.

March 18, 1921. Patient given roentgen-ray treatment as follows: 25 ma.m., 80 k. volts, 3 mm. aluminum filter, skin target distance 10 inches. Area exposed, abdomen over stomach region.

Patient did not feel any evil effects from treatment, returned to the ward, ate her meals regularly and on the fourth day following treatment, the fractional test was as follows:

Free	*HCl*	*Total Acid*
1st	15	50
2nd	20	60
3rd	20	75
4th	35	90
5th	55	95
6th	65	95
7th	65	95
8th	40	70

Patient continued on her liberal diet. Subjectively, she felt somewhat relieved, and on

*Read at the Second Annual Meeting of the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY, Portland, Ore., May 27, 1921.

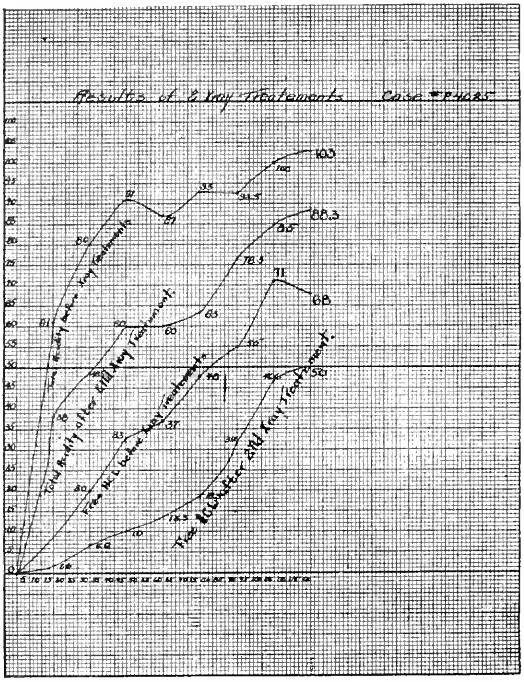

Chart 1.

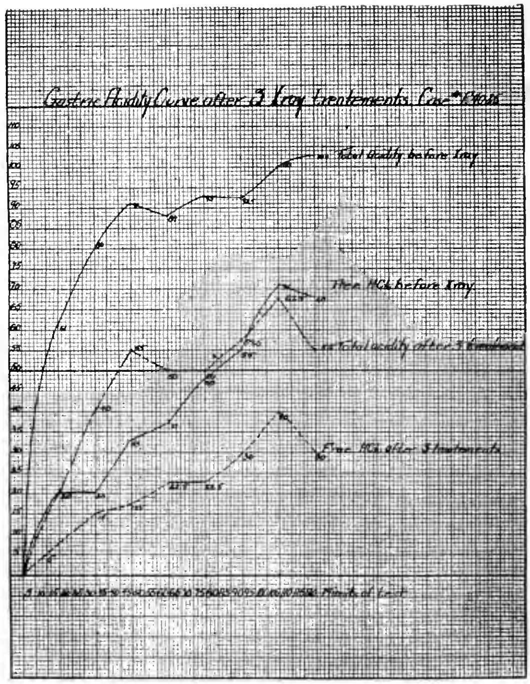

Chart 2.

March 28, 1921, ten days after her first treatment, another roentgen-ray treatment to abdomen over stomach region was given as follows: 35 ma.m., 80 k. volts, 3 mm. aluminum filter, 10 inch skin target distance. Area exposed, abdomen over stomach region.

On the following three days, successive test meals were taken as follows:

	3:29:21		3:30:21		3:31:21	
Free	HCl	Total Acid	HCl	Total Acid	HCl	Total Acid
1st	0	40	5	50	0	25
2nd	0	40	10	55	10	50
3rd	5	60	15	55	10	65
4th	10	60	20	55	10	65
5th	10	60	25	60	20	70
6th	35	75	35	75	25	80
7th	40	85	50	85	50	85
8th	55	85	30	85	65	95

March 31, 1921. Since the second treatment the patient, subjectively, feels much better. She eats all the food served to her and says that she enjoys it because she is no longer continuously annoyed by gaseous and sour eructations.

From the three tests taken after roentgen-ray treatment, as compared to the three tests taken before treatment, an appreciable decline in both free HCl and total acid is apparent. An average taken for each fifteen-minute period before treatment as compared to the average of those for a similar period after two roentgen-ray treatments shows the following results:

	Free HCl		Total Acid	
	Before	*After*	*Before*	*After*
1st	20	1.6	61	38.6
2nd	20	6.6	80	48.6
3rd	33	10	91	60
4th	37	13.3	87	60
5th	48	18.3	93	63.3
6th	55	31.6	92.5	76.6
7th	71	46.6	100	85
8th	68	50	103	88.3

See chart for reconstructed curves on basis of these figures.

Note: Averages for each 15 minute period made up from the three successive tests before and after treatment as given above.

As the patient seemed much improved after two treatments, and as her gastric analysis still showed a hyperacidity curve, further roentgen-ray therapy seemed advisable.

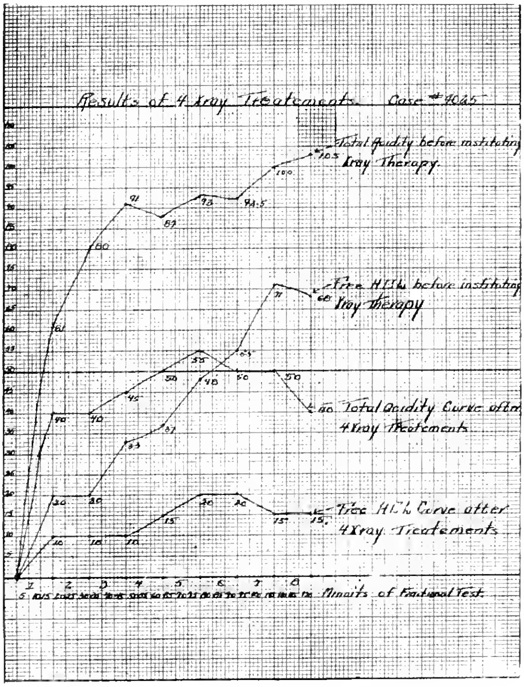

Chart 3.

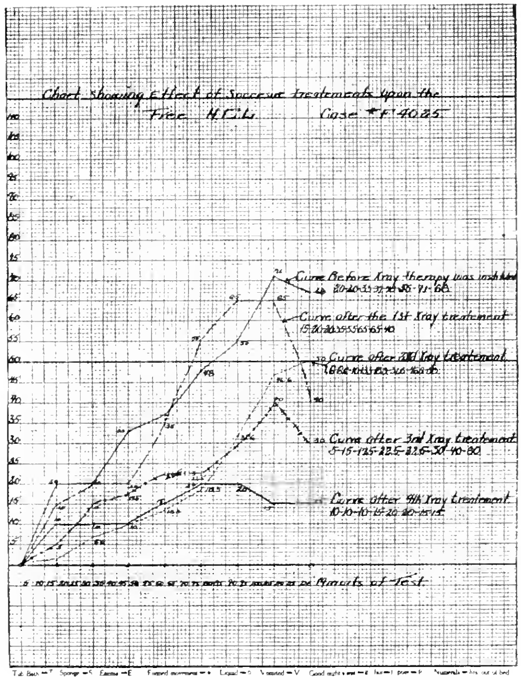

Chart 4.

Accordingly, on April 5, 1921, the following treatment was given: 30 ma.m., 8 k. volts, 3 mm. aluminum filter, 10 inch skin target distance. Area exposed, abdomen over stomach region.

A few moments after this (the third)

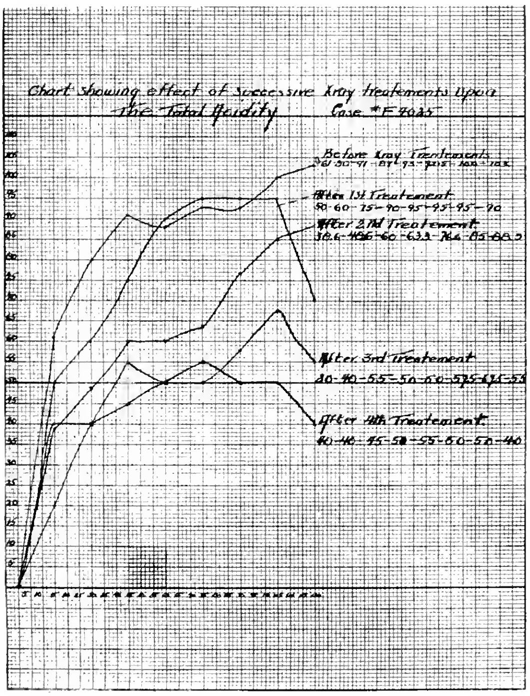

Chart 5.

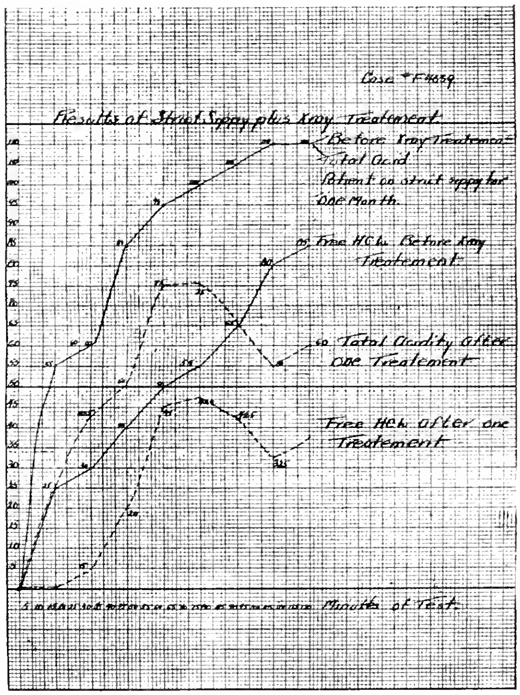

Chart 6.

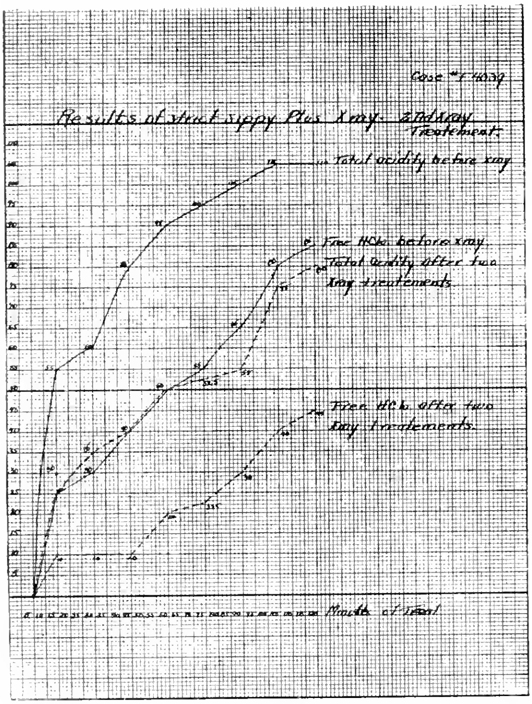

Chart 7.

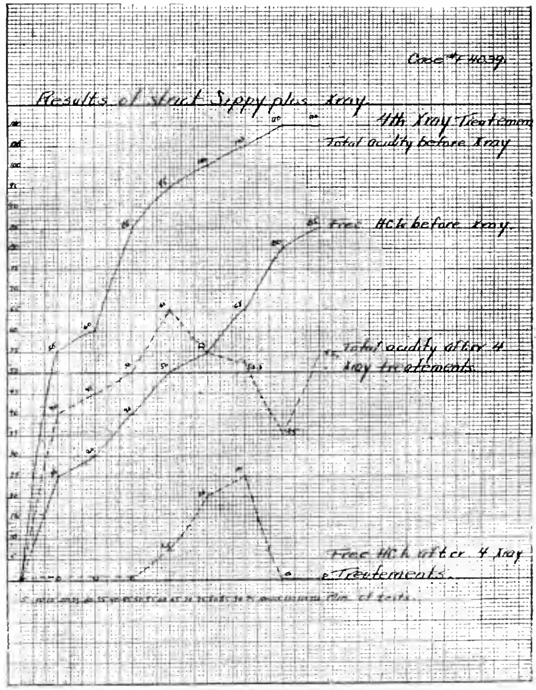

Chart 8.

treatment, an Ewald fractional test was taken to determine whether or not the effect of the therapy was immediate. The results of the test were as follows:

	Free HCl	*Total Acid*
1st	5	20
2nd	15	40
3rd	17.5	55
4th	22.5	50
5th	22.5	50
6th	30	57.5
7th	40	67.5
8th	30	55

These figures show an immediate reduction in both free HCl and total acid.

The patient was allowed to continue upon an unrestricted diet as before, and after a period of ten days another test was taken in order to determine whether the reduction in the acidity had changed to any appreciable extent. No roentgen-ray therapy was given during this interim.

The results of the test were as follows:

	Free HCl	*Total Acid*
1st	5	30
2nd	10	42.5
3rd	10	55
4th	25	60
5th	35	60
6th	30	55
7th	40	65
8th	30	55

These figures show that over a period of ten days there had been very little if any change in the gastric acidity.

On April 19, 1921, another roentgen-ray treatment was given as follows: 35 ma.m., 80 k. volts, 3mm. aluminum filter, 10 inch skin target distance. Area exposed, abdomen over stomach region.

After this treatment, a period of one week was allowed to elapse before the Ewald fractional test meal was taken. The results of the test meal are as follows:

	Free HCl	*Total Acid*
1st	10	40
2nd	10	40
3rd	10	45
4th	15	50
5th	20	55
6th	20	50
7th	15	50
8th	15	40

After this test, patient left the hospital practically free from all symptoms of gas-

tric distress. We hope to have her report at monthly intervals in order to determine the permanency of the result.

COMPARATIVE TABLE OF GASTRIC ACIDITY BEFORE ROENTGEN-RAY THERAPY AND FOLLOWING EACH SUCCESSIVE TREATMENT

Free HCl

Before any X-Ray		After 1st Treatment	2nd	3rd	4th
1st	20	15	1.6	5	10
2nd	20	20	6.6	15	10
3rd	33	20	10	17.5	10
4th	37	35	13.3	22.5	20*
5th	48	55	18.3	22.5	20
6th	55	65*	31.6	30	20
7th	71*	65	46.6	40*	15
8th	68	40	50 *	30	15

Total Acid

1st	61	50	38.6	20	40
2nd	80	60	48.6	40	40
3rd	91	75	60	55	45
4th	87	90	60	50	50
5th	93	95*	63.3	50	55*
6th	92.5	95	76.6	57.5	50
7th	100	95	85	67.5*	50
8th	103*	70	88.3*	55	40

*The asterisk marks the highest point for each test and you will note that with each succeeding treatment, the acidity never reaches the highest point reached in the previous test.

CASE F.4039. Man (D. E.). Age forty-six.

History for past twelve years typical of duodenal ulcer. Patient entered hospital on account of vomiting and passing by rectum a large quantity of blood. After control of hemorrhage, roentgen examination confirmed diagnosis of duodenal ulcer. Gastric analysis showed total acidity 85 and free HCl 35.

Patient continued on strict Sippy treatment for obstruction type of peptic ulcer, and in spite of the increasingly large doses of alkalies, it was impossible to control the high acidity. Although the patient gained in weight and felt much better, he complained of some discomfort and pain in his epigastrium.

From time to time, samples of gastric content were taken (one half hour after last powder in accordance with Sippy's method, 9:30 p.m.) and we found that the acidity was exceedingly high in spite of the fact that the patient had been under treatment for a period of six weeks. At one time, patient showed total acid 125 and free HCl 55.

In view of the results obtained in the previous case (4025) in controlling the acidity, it was decided to combine the roentgen-ray therapy with the Sippy treatment.

The following Ewald test was taken to establish the nature of the gastric acidity before administering roentgen rays.

April 4, 1921, Fractional Test (Ewald Meal)

Free HCl		Total Acid
1st	25	55
2nd	30	60
3rd	40	85
4th	50	95
5th	55	100
6th	65	105
7th	80	110
8th	85	110

April 6, 1921. Roentgen-ray treatment over stomach as follows: 35 ma.m., 80 k. volts, 3 mm. aluminum filter, 10 inch skin target distance.

Another fractional test was taken as follows:

Free HCl		Total Acid
1st	0	25
2nd	5	42.5
3rd	20	50
4th	45	75
5th	47.4	75
6th	42.5	65
7th	32.5	55
8th	37.5	60

Owing to this very striking result, the test was repeated the following morning, April 8, 1921:

Free HCl		Total Acid
1st	5	25
2nd	15	35
3rd	20	50
4th	20	50
5th	25	55
6th	22.5	45
7th	30	55
8th	45	55

During the interval between tests, the patient was taking large quantities (double doses) of alkalies hourly from 6:30 a.m. until 9:30 p.m.

April 14, 1921, patient was given another roentgen ray treatment as follows: 35 ma.m., 80 k. volts, 3 mm. aluminum filter, 10 inch skin target distance.

He was instructed not to take any Sippy powders for forty-eight hours, and then the following test was taken on April 15, 1921:

Free HCl		Total Acid
1st	5	35
2nd	10	45
3rd	17.5	50
4th	20	55
5th	25	60
6th	42.5	82.5
7th	60	85
8th	60	85

The patient again resumed the Sippy treatment and after a period of twenty-four hours, another test was taken on April 17, 1921, as follows:

Free HCl		Total Acid
1st	10	30
2nd	10	35
3rd	10	40
4th	20	50
5th	22.5	52.5
6th	30	55
7th	40	75
8th	45	80

Although there was a definite increase in both free HCl and total acidity over the tests taken following the first roentgen-ray treatment, the patient felt fine and was entirely free from pain.

On April 18, 1921, the following roentgen-ray treatment was given: 35 ma.m., 80 k. volts, 3 mm. aluminum filter, 10 inch skin target distance.

On April 25, 1921, another treatment was given as follows: 35 ma.m., 80 k. volts, 3 mm. aluminum filter, 10 inch skin target distance.

Two days later, April 27, 1921, an Ewald fractional test was taken:

Free HCl		Total Acid
1st	0	40
2nd	0	45
3rd	0	50
4th	7.5	65
5th	20	55
6th	25	52.5
7th	0	35
8th	0	55

On April 28, 1921, at 10.30 p.m., one half hour after the last Sippy powder had been taken, a sample of gastric content showed the following: free HCl 25; total acid 60. The patient had gained over 20 pounds in weight, was entirely free from pain, and had an excellent appetite. He was discharged from the hospital with instructions regarding diet, etc.

The dosage as given in these cases seemed to give the most favorable results without any disturbance. Several patients treated with higher doses were nauseated and very miserable for twelve hours following the treatment. While we have not had the opportunity to observe the time that these results will last, several of our cases have been free from symptoms from three to six months, and it is very difficult to get these patients to return for gastric analysis while they are free from symptoms.

We are indebted to Dr. S. H. Hurwitz, Dr. A. Nahman, and Dr. E. O. Jellinek of the Medical Staff of the Mt. Zion Hospital for hearty cooperation in this work.

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TREATMENT OF LEUKEMIA*

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THE disease "Leukemia", as it was described in the text-books and taught in medical schools at the time I attended, seemed to comprise a fairly well-defined group of conditio s which could be subjected to a clear-cut classification. It appeared very simple to divide the leukemias into the myelogenous and lymphatic types, and the differential diagnosis was well defined both as to blood pictures and clinical findings. Allied with the leukemias, but having a distinct entity, Hodgkin's disease was usually described in the succeeding chapter.

Since that time a great deal of work has been done along this line, and especially within the last few years, as a result of which, each of the newer systems of medicine devote a good deal of space to the subject and the recent journals have numerous articles by different investigators.

All the writers have added a little to the general knowledge on the subject, but each has viewed it from a slightly different angle and has attempted a modification of the old classification.

The tendency of modern writers seems to be twofold: first, they tend to broaden the scope of the leukemias to include many allied conditions, and second, they tend to subclassify with greater detail and in so doing have introduced many terms, the exact meaning of which is only clear to the author originating them.

Under the subject of leukemia, one finds described not only the original acute and chronic forms of splenomyelogenous and lymphatic leukemia, but also Hodgkin's disease, aleukemias, subleukemias, myeloses and lymphoses, chloromas, lymphomas, granulomas, sarcomas and primary anemias.

One patient of mine who returned to the East, was diagnosed as an "aleukemia leukemia," and a splenectomy was done. I am glad to say the results of the operation were very gratifying in spite of the apparent meaningless nature of the diagnosis.

It is very probable that the name meant a very definite condition or disease to the operator, but it failed to convey any additional meaning or information to myself or any of the other men interested in the case.

For general usefulness, therefore, it seems rather hard to improve on the original text-book classification which is, at least, simple in application and conveys a very definite impression when applied to a condition. It is true that no two leukemia cases are exactly alike, but neither are any two individuals. It therefore seems more rational to the writer to assign a case definitely to one or the other of the main groups, and then elaborate the particular findings and course of the disease.

The two main groups are the myelogenous and the lymphatic types. In the myelogenous form there is a hyperplasia of the white cells originating in the bone-marrow. These are the granular forms of white blood cells. The lymphatic form is characterized principally by an increase in the lymphocyte series of non-granular white blood cells. In the myelogenous form the spleen and bone-marrow activity is principally increased, while in the lymphatic form there is usually a general hyperplasia of lymphatic tissue throughout the entire lymphatic system.

Both these conditions are often present to a varying degree in the same patient, and from either the physical findings or blood picture it is very difficult to state definitely which series of findings predominates. Certain other cases have very few of the typical findings of a leukemia, but more nearly approach conditions formerly considered as entities, such as Hodgkin's disease, sarcomatosis, primary splenic anemia or pernicious anemia.

A blood slide of one of the cases which I am reporting was sent to another laboratory after the W. B. C. had dropped to normal or a little below and was reported back as a pernicious anemia. This conclusion was

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very well grounded with a white count of 5,600, red count of 2 million, and hemoglobin 30 per cent.

So much has been written in the journals recently on the treatment of these cases by both the roentgen ray and radium that it is probably very familiar to you all. Personally, I have never used radium although equipped to do so, as it does not seem rational to me to attempt to use this agent in a condition that is so widespread. We all know that the effect of radiation decreases as the square of the distance from the source, and when radium is used the effect is limited to a very small area. So far as I have been able to learn, no one has a sufficient quantity of radium or the time and patience to make anything like the general application possible with the roentgen ray. However, many men report very gratifying results by the application of radium over the splenic area alone.

Benzol, as a therapeutic agent, was used a great deal a few years ago, but is apparently used less today than formerly. Billings used it in connection with the roentgen ray on numerous cases, but I understand he has practically given it up. While it may help to bring down the white count very rapidly, the consensus of opinion seems to be that the benefit derived is more unstable and the than when it is not used. Although recurrences always do occur sooner or later, I have seen but two cases of leukemia which did not show a very marked improvement under roentgen-ray therapy. These were of the acute fulminating type, one of myelogenous leukemia in a boy of fourteen, who died within a month of the time a diagnosis was made and within two weeks of the time treatment was begun. The other was of the lymphatic type, and death ensued within one week of the first symptoms.

In the first case, although very small dosage was given, I have never been quite sure that his death might not have been hastened by the increased toxemia. Although practically every case shows a great improvement, this improvement is only temporary, but I believe there is no other *fatal* disease for which we can do so much as in this class of cases.

Just how radiation, either the roentgen ray or radium, acts, is still largely theoretical. From my own experience it seems that it makes very little difference where the radiation is applied, but the effect is apparently proportional to the amount of blood radiated. Whether this is due directly to the effect on the blood elements, or by their destruction some substance is liberated which secondarily affects the production of the blood elements, is really immaterial.

I have noticed untreated glands in lymphatic leukemia and Hodgkin's disease regress in size, and nearly always in the true leukemias there is a larger drop in the white cells and an increased toxemia when treatment is given over blood-filled organs such as the spleen and liver, than in treatment over the long bones.

Each individual case must be watched carefully during treatment for any signs of increased toxemia and the amount of treatment gauged accordingly. One can usually count on the blood picture improving for a considerable time after treatment has stopped, and for this reason I do not attempt to get the blood count below 15,000 to 25,000, depending on the rapidity with which it is falling when treatment is stopped. After the blood has reached a practically normal white count there is still a great deal which can be done to benefit the patient. The red count is usually low and also the hemoglobin. These must be built up by rest, good food, tonics, iron by mouth or hypodermically, or by transfusion.

Of late years there is a growing tendency toward splenectomy, after reduction of the size of the spleen by radiation and building up the patient's general condition. The Mayo Clinic, up to January 1, 1918, had given a mortality of 93 per cent. Since that date and up to June, 1920, they have operated on 26 cases with a mortality of 38 per cent. Of these, 5 are in good condition and 2 in fair condition beyond the usual life expectancy of the disease. While these figures are promising, it is too early to decide definitely on the value of splenectomy in these cases.

As to technique, I use a full 8 inch spark gap between ball points with a 4 mm. aluminum filter and sole leather, and usually give a 5 to 10 X dose daily, using a different area each day, and treating up one side of the body and down the other. This treatment is reduced to every other day if there is too much toxemia. The initial course is contin-

ued until the white count is nearly normal. Regular blood counts are made thereafter and another series of treatments given as indicated by the blood picture and the patient's general condition. It will be seen that the above dosage is more stimulative than destructive in action.

I wish to report 2 cases of myelogenous leukemia coming under my care in the past year, and of which I have fairly complete records. One other case, previously referred to as an aleukemia leukemia, more nearly approached the lymphatic type. This was in a physician who underwent a splenectomy, practically during the acute stage, but is in very good health today and attending to his practice.

A fourth case was seen very recently. A man was taken sick on a Thursday, complaining only of malaise, slight fever and a small enlargement of the cervical glands. The W. B. C. on Saturday, on his admission to the Hospital, was 600,000. On Sunday I gave a very small dose of roentgen rays. Monday he became delirious, gradually sinking into a stupor with meningeal symptoms, with death occurring on the sixth day of the disease.

Both of the other cases are of the chronic myelogenous type and have shown the usual very marked improvement.

CASE I

Miss C. M., American, aged forty-nine, school teacher, single. No previous sickness since childhood except a supposed ulcer of stomach from which she lost three weeks school work, the only time lost in twenty-four years of teaching. Family history negative.

She first consulted a physician in May of last year but had noticed swelling of feet and legs the previous fall. For two months before consulting a doctor had noticed some pain in left side in region of spleen. There was also some shortness of breath on exertion. Her last school year was rather trying on account of aching in feet and limbs.

Physical examination showed patient in good flesh but slightly anemic. The hair and teeth were in good condition. Tonsils atrophic; thyroid normal. Heart and chest normal except for systolic murmur at apex.

Abdomen showed dullness beginning at 7th interspace in left axillary line and extending to crest of ilium, caused by a large dense mass occupying the position of the spleen and extending from costal border to crest of ilium and as far as the median line in front. No other glandular enlargements.

Bones not painful on pressure or tapping. Some edema of legs and feet.

The first blood count, taken before admission to the hospital, showed a total white count of 224,000 with 45 per cent polys, 22 per cent lymphocytes, 8 per cent basophils and 25 per cent myelocytes, with about 15,000 nucleated reds per c. mm.

The large number of myelocytes, together with the clinical findings, places this case definitely in the class of the chronic myelogenous type.

CASE II.

Mrs. E. H., aged forty-two, American, rancher's wife. Family history entirely negative. Past history, measles, whooping-cough when child. Had influenza one year ago, lasting for six weeks.

Has had no children. There was one pregnancy ten years ago, but a miscarriage occurred at six weeks. Menses always regular, usually flowing five to six days. Patient thinks she had attack similar to present one four years ago, but at that time was only sick about one week.

Present trouble began last winter. She complained of feeling weak and had no energy. Weakness increased up to January 22nd of this year, at which time she was confined to her bed for about two weeks. She complained of nausea and some vomiting. After two weeks' confinement she was able to be up for a short time but was extremely weak.

A physical examination at her entrance to the Hospital on March 14th, showed a fairly well-nourished individual with a very marked greenish yellow discoloration of the skin all over the body. There was some yellowish discoloration of the conjunctivae. The mucous membranes were very pale. The patient was too weak to stand.

The cervical, axillary and inguinal glands were just palpable. The teeth were in fairly good condition,there being only one showing

a granuloma. This was removed. The chest examination was entirely negative. The abdominal examination showed the spleen so much enlarged that it entirely filled the left side of the abdomen and extended to the right of the navel, about 1½ inches. This entire area was very tender on palpation. The liver was very slightly enlarged and was tender. The pelvic examination was negative. Reflexes normal.

I have records of the differential counts of these two patients at very frequent intervals, but from my experience, which is well illustrated by these 2 cases, more credence should be placed on the total white count in conjunction with the condition of the patient than on the differential count, as determining the progress of the case and the treatment required. Case I showed on May 20, 1920, a 35 per cent myelocyte count; on June 23rd a 3 per cent myelocyte count; and on June 29th a 23 per cent myelocyte count, although the total white count and the patient's condition showed a steady improvement during this time.

Case II showed a nearly normal polymorphonuclear count throughout the course of the disease, the lowest count being 53 and the highest 74 per cent. Only one count showed as much as 1 per cent of typical myelocytes, although the total count of granular cell elements, composed of transitional eosinophils, basophils, large mononuclears and myelocytes showed a definite increase in percentage over the normal. It is for this reason and the fact that the clinical symptoms showed no other glandular enlargements except the spleen, that I classify this case as of the myelogenous type. It is not the classical text-book picture, being atypical in several respects, but more nearly resembles the myelogenous form than the lymphatic.

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SUBOCCIPITAL POTT'S DISEASE*

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THE frequency of the location of spinal tuberculosis is in the following order: first, dorsal spine; second, lumbar spine; third, cervical spine. In the last region the parts least frequently affected are the first and second cervical vertebrae; hence Pott's disease involving these segments is comparatively rare.

My special attention was first called to the condition by the case which is reported below, and on a search of the literature I was surprised to find reference to the condition very meager, particularly in our own tongue. The French literature is more extensive on the subject; in fact, had I not, only a few days before seeing this case, come across an article by Galland (see bibliography), I might not have been so fortunate as to have spotted it. Hence a brief résumé of the subject may not be unwelcome.

Since tuberculosis of the spine invades primarily the spongy bone, the natural places to expect to find it, in the two particular vertebrae here considered, are the odontoid process and body of the axis, and the lateral masses of the atlas. This is the case, and from these regions it may extend to the anterior arch of the atlas, and to the condyles of the occiput.

According to the amount of bone destruction, various luxations take place which give rise to certain more or less characteristic deformities, as well as to numerous secondary nerve pressure symptoms which have at times led the diagnostician far afield in judging the true condition. Such was the situation in a case reported by Merklen and Shaeffer, of a woman, aged seventy, in whom secondary nerve symptoms so dominated the picture that the true cause of the

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symptoms was not discovered. It seems a matter worthy of note that in an examination which was complete and exhaustive in every other feature, not once was the possibility considered that roentgen methods could offer any help in the solution of the problem, when this diagnostic means was obviously the one best calculated to provide that solution. In this case autopsy alone revealed the true condition.

Fig. 1. Compression of right lateral mass of atlas in case of suboccipital Pott's disease.

Where there is destruction of the lateral mass of the atlas, either on one side or on both sides, the occiput may settle down and forward and cause the odontoid process to penetrate the foramen magnum, and there will ensue various symptoms of pressure on the upper cord and bulb that will greatly confuse the clinical picture.

Previous to the time of compression of diseased bone, at least so far as it causes pressure symptoms, the patient will usually seek aid for severe pain in the posterior portion of the neck, high up, particularly on motion, and due in large part to the muscular spasm on the side affected. A typical picture of ordinary torticollis is seen, plus the pain. Motion of the head is also voluntarily limited and the chin is apt to be supported by the two hands. The onset may be unexpectedly rapid and a fairly acute history may be given.

Prevertebral or paravertebral abscess may form and travel down the cervical fascia pointing at any of the various points along the way, even, as in a case reported by Rugh (see bibliography), going as far as the lumbar region before showing itself.

As to points of differential diagnosis, aside from the distinction from simple torticollis, authors place considerable weight on differentiation from mastoid disease and the various symptom syndromes due to compression of nerve roots, or even from cerebellar tumor. Since apparently trustworthy observers have confessedly been misled in their diagnosis in these points with, of course, disastrous results to the patient, and no doubt no end of chagrin to themselves, it is apparent that suboccipital spinal caries must be considered when one of the atypical cases of mastoiditis or of pressure on the lower brain or lower cranial nerves is up for diagnosis. Manifestly the diagnosis, from a therapeutic standpoint, is tremendously important; for the treatment, for instance, of acute mastoid disease and spinal caries is exactly opposite, in that in the former surgery is to be considered, and in the latter, certainly not.

Fig. 2. Normal atlas and axis taken through the nose.

Case Report. L. S., female, aged eleven, was referred to me on December 27, 1920, by Dr. F. S. Ryan with the following history: Patient had had mumps, measles and scarlet fever together about five years ago. Pertussis and catarrhal jaundice of three weeks' duration in September and October,

1920, with fever practically all the time. There was marked icterus and some tenderness in the region of the gall-bladder.

The present illness began suddenly with pain in the neck, especially on movement. She fell off some boards about two weeks previously, but does not remember that she twisted or hurt her neck. No chills or fever.

Examination revealed a fairly well nourished child, quite pale, but eyes and skin clear. The patient held the head tilted to the right, that is, the point of the chin was deflected to the left, and the head was apt to be supported by the hands in moving the body as in getting onto and off the table. Movement of the head was extremely painful and evoked marked muscle spasm in the neck muscles. The reflexes were normal or slightly exaggerated. The heart, lungs and abdominal viscera were negative. The urine was normal. The blood showed a hemoglobin of 60 per cent and a leucocyte count of 8,000.

The patient passed from under Dr. Ryan's observation for a time while trying various electrical treatments and finally returned to him, and he requested the roentgen examination which revealed a destructive process in the right lateral mass of the atlas, with compression, thus allowing the head to tilt to the right.

In conclusion, a word or two on technique might be of value. Our usual method of getting an anteroposterior view of the first two cervical vertebrae is by exposing through the opened mouth upon a plate placed at the back of the neck. This is a maneuver which requires some nicety of judgment to succeed in missing the teeth and the occiput, and obtain a view of the two vertebrae with a minimum of distortion.

If the patient has an occiput which slopes up abruptly enough, we can usually succeed in getting the joint between the atlas and axis and most or all of the odontoid process. If he is minus his front teeth we are aided still more. However, there are a large number of patients who unfortunately have all their teeth and whose occiputs have considerable overhang. For such as these the method suggested by Galland offers a solution. This method consists in passing the vertical ray through the nasal air spaces at right angles to the plate and to the first two vertebrae.

We thus get a minimum of distortion and, aside from the superimposing of some of the fine bony network of the pneumatic sinuses, a very fair view of the region. I have tried it in several cases, and where there is not too much hypertrophic tissue in the nose the results have been fairly satisfactory. Of course, it will never take the place of a good view through the mouth.

SUMMARY

Suboccipital Pott's disease is a relatively rare condition, but must be considered in the differential diagnosis of many cases of mastoiditis, torticollis, and symptom-complexes indicating pressure on the bulb or lower cranial nerves.

It is more commonly found in children, but also appears in adults, even in those of advanced age.

Proper roentgen examination in all cases under suspicion should clear the diagnosis successfully.

In cases where it is impossible to get a clean anteroposterior view of the atlas and axis through the mouth, the transnasal method should be tried.

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X-RAY TREATMENT OF TOXIC GOITER*

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THE *x*-ray treatment of hyperthyroidism is one of the newer contributions to medicine. The reviews concerning the technique and dosage and the extent and duration of results have in most cases not been complete. We should like to report 35 cases from our private and dispensary clientele observed from January, 1920, to the present time and on whom roentgen treatment was completed before February, 1921.

As concerning the older literature we will review it briefly. We wish to mention from the German literature, Stegmann, 1905, Eiselberg, 1909, Rave,[1] 1911, and Nagelschmidt, 1912; from the Scandinavian literature, Forssell,[2] 1914, Fischer,[3] 1916, and recently, Nordentoft,[4] 1921; in this country the earlier reports of William, 1902, Mayo, 1904, Beck, 1905, and Pfahler and Zulick.[5] The last article in the American literature is by Means and Aub,[6] 1919, whose excellent work reopened the *x*-ray treatment of the disease in this country.

We prefer to omit a tabulated abstract of our cases and leave this for a more detailed report to appear in the Proceedings of the Society.

DATA AND METHODS

The material includes cases of hyperthyroidism which came under the observation of the medical service of the University Hospital, dispensary and private practice during a period of approximately twenty months. No attempt at selection of cases has been made. The series does not include cases admitted to the surgical service, some of which were more toxic and in which surgical treatment was immediately resorted to. For better interpretation of data the cases have been divided into three groups.

The first group consists of cases of toxic goiter with and without exophthalmos varying from mild to severe.

The second group consists of six post-operative cases of exophthalmic goiter, and is included because it represents those cases in which medical treatment is instituted only because surgical treatment has already eliminated itself.

The third group includes three cases of thyrotoxic adenoma which received *x*-ray treatment and are reported for whatever value they may have. No attempt was made to increase the number of this type of case. The individuals in these series, for the most part, led their usual lives and no other coincident treatment was carried on. A few of the cases were under hospital treatment for a few weeks, but they form a relatively small part of the series. Most of the observations have been made at the office and the dispensary. Estimation of the activity of the thyroid gland has been based on the metabolic rate, clinical signs and symptoms, such as pulse rate, character of the gland, eye signs, tremor and nervousness. Such data have been incomplete in some of the cases but in most instances have been sufficient to enable conclusions to be drawn as to the results of treatment. The determination of the metabolic rate has been attempted in each case once every three weeks corresponding numerically to the *x*-ray treatments, and, in order to avoid an immediate increase that

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might follow during the first few days, usually eight to ten days following exposure. In some patients fewer determinations were possible, but in all cases the last metabolic rate has been recorded and checked from three to six weeks after the last treatment. The gasometer method of determining the metabolic rate has been employed. Tissot's spirometer has been used for the collection of the air, and for its analysis the Haldane apparatus. Care has been taken to have the patient in the post-absorptive stage, that is twelve to fourteen hours after food intake, with sufficient period of rest before each determination.

TECHNIQUE

These cases were all treated with a standard dosage at three-week intervals. The radiation consisted of 30 milliampere-minutes of ray filtered through 4 mm. of aluminum and one thickness of sole leather. The target-skin distance was 8 in., and the voltage was equal to an 8 in. spark gap measured between blunt points. Three portals of entry were used, one over each lobe of the thyroid and one over the thymus. If there was not marked improvement noted at the completion of the fourth treatment the dosage was increased to 34 milliampere-minutes, the other factors remaining constant. It is worthy of note that in several of the cases where improvement had been tardy, a rapid improvement, both in the metabolic rate and in the general well-being of the patient, was coincident with the increased dosage. This is of interest in that most of the European roentgenologists have insisted on large doses at long intervals. While it has been difficult to interpret their induction coil and gas tube technique in terms of interrupterless transformer and the Coolidge tube, the constant reiteration through their articles that small doses stimulate and large doses inhibit thyroid activity is worthy of note. We furthermore believe that there is much less risk of a cumulative skin reaction developing if treatments are given not oftener than once in three weeks.

It must be emphasized that the closest coöperation possible between the referring physician and the roentgen therapist is necessary. A clear understanding is essential as to which assumes the responsibility for the clinical observation and the metabolic readings upon the patient. Otherwise intercurrent infections may be overlooked or over-treatment may result.

DISCUSSION

Group I consists of cases of toxic goiter including all degrees of activity. The average case is one of moderate severity as evidenced by a mean metabolic rate of plus 33 per cent. Clinically the same estimation is possibly evidenced by the fact that most of the group were ambulatory patients. We have not attempted to gauge clinical improvement between various treatments. However, a summation of clinical results is possible following the series of treatments, both as to the patient's condition subjectively and objectively. The pulse rate has been diminished, tremor and nervous symptoms including insomnia have been less marked. As would be expected there has been no marked alteration in the eye signs and character of the gland except in Case 10 in which a markedly enlarged and indurated gland disappeared as if by magic with correspondingly subjective improvement. Fall in heat production followed two exposures to x-ray and the indurated character of the gland and the subsequent course suggest an acute thyroiditis.

Two cases received no appreciable benefit as indicated by lack of clinical improvement and heat production. One of these, Case 17, was a boy of fourteen with a diffusely enlarged vascular gland and marked exophthalmos. Operation was later resorted to with subsequent clinical improvement and fall in metabolic rate to minus 17 per cent. Four months later the basal metabolism had again returned to plus 4 per cent. Case 18, a woman twenty-six years of age, with diffusely enlarged vascular gland but no exophthalmos, showed very little response after three treatments and was later operated. For accuracy it should be stated that Case 2 responded to x-ray therapy only after the removal of badly infected tonsils which undoubtedly had some etiological relationship to her hyperthyroidism. Recently we have had an interesting (incomplete) case. A girl with symptoms of hyperthyroidism without exophthalmos, showed an increased basal

GROUP I.

Case	Sex	Age	Symptoms before treatment	Duration of treatment in mos.	Number of treatments	Basal Metabolism Before	Basal Metabolism After	Pulse Before	Pulse After	Tremor Before	Tremor After	Thyroid Gland Before	Thyroid Gland After	Eye Signs Before	Eye Signs After	Remarks
1. WH.	♂	47	Nervousness, weakness, shortness of breath, heart fibrillation 4 mos.	3	5	+46	+28	148	136	++	++	Small, diffuse, vascular.	No change	++	++	Feels much better Works as engineer
2. ML.	♀	16	Slight nervousness Aching neck, frequent sore throat 6 mos.	3	4	+50	+21	120	100	++	+	Large, diffuse, vascular.	Slightly diminished in size	+	+	Subjectively much better Gain in wt. Had tonsillectomy.
3. K.	♀	32	Moderate nervousness	–	1	+17	+10	–	–	+	–	Small, diffuse	No change	+	–	Improved
4. B.	♀	38	Insomnia Nervousness	5	6	+21	+3	110	102	+	+	Small, diffuse	No change	0	0	Somewhat improved
5. MA.	♀	24	Weakness Nervousness	4	6	+25	+13	110	100	+	+	Small, diffuse	No change	+	+	Slight improvement clinically
6 JKA.	♀	38	Palpitation Weakness	6	9	+25	+13	110	80	+	+	Moderate enlargement	No change	0	0	Palpitation diminished Strength increased
7 ID.	♀	21	Weakness Nervousness	1.5	3	+19	–9	–	–	–	–	Small, diffuse	No change	–	–	Feels better.
8. EF.	♀	28	Insomnia Nervousness	6.5	10	+23	–2	100	–	+	+	Slight, diffuse	No change	0	0	Moderate improvement.
9. MJ.	♀	19	Weakness Nervousness	6	9	+45	+4	–	–	+	+	Moderately enlarged Diffuse Vascular	Slight decrease in size	+	+	Slight improvement.
10. MH.	♂	28		2.5	3	+71	+31	148	100	++	+	Large diffusely indurated Vascular	Marked decrease in size Induration disappeared	++	++	Remarkable improvement. Can sleep. Is stronger and able to work. Probably acute thyroiditis.
11. GM.	♀	33	Nervousness Tired Loss of wt. Frequent menstruation	2	3	+22	–6	98	90	+	–	Diffuse, moderate enlargement	No change	0	–	Marked improvement. Returned to work
12. GW.	♂	16	Insomnia Nervousness Palpable gland	1.5	2	+55	–1	90	90	+	±	Diffuse Extensive enlargement	No change.	0	0	Able to sleep. Otherwise same.
13. MS.	♀	39	Palpitation Perspiration Nervousness Frequent micturition.	1.5	2	+16	+4	110	74	+	slight	Diffuse enlargement	No change	0	0	Symptoms less marked
14 GB.	♂	22	Loss of weight Nervousness Speech defect	1	1	+37	–9	98	82	+	Present on excitement	Slight diffuse enlargement	No change	0	0	Improved Difficulty in speech only on excitement
15. GS.	♀	23	Palpitation Nervousness	4	5	+22	+4	100	90	+	+	Small, diffuse	No change	0	0	Feels much better.
16. LP.	♀	37	Weakness Nervousness Abdominal pain	4	3	+28	+13	100	102	+	+	Small, diffuse enlargement	No change	++	++	Patient feels better
17. AL.	♂	14	Weakness, shortness of breath – 2 yrs.	2	3	+33	+24	120	110	+	+	Moderate diffuse enlargement Vascular	No change	+++	+++	Only very slight improvement After operation rate dropped to –19%.
18. LF.	♀	26	Night sweats Palpitation 5 mos.	2	3	+37	+32	116	110	+	+	Moderate diffuse enlargement Vascular.	No change.	++	++	No improvement noted.
19. LB.	♀	38	Palpitation Nervousness Exophthalmos.	4	4	+35	+13	124	82	+	–	Diffuse enlargement. Vascular.	No change.	++	++	Subjectively improved
20 MP.	♀	21	Palpitation. Nervousness. Exophthalmos	5	4	+28	–3	140	90	+	–	Moderate enlargement	Smaller.	0	0	Doing all her work. No symptoms present.
21 KE.	♀	27	Loss of wt. Nervousness Insomnia	6	3	+38	–1	110	95	+	–	No enlargement	No change	0	0	Gained 15 pounds Insomnia disappeared. Nervousness gone
22. ST.	♀	38	Loss of wt. Nervousness. Tachycardia	3	4	+42	+8	120	110	+	+	No enlargement.	No change	+	+	Tachycardia still present. Insomnia gone Feels fine
23. PK.	♂	27	Nervousness Pericardial pain Vomiting.	6	8	+21	–5	130	110	+	0	Diffuse enlargement.	No change	0	0	Gastric symptoms disappeared. No pains Gained 10 pds.
24. LR.	♀	36	Nervousness Weakness Shortness of breath.	4	5	+25	+5	140	120	+	+	Diffuse enlargement.	No change.	0	0	All symptoms disappeared
25. GB.	♀	43	Nervousness Crys easily. Marked tremor.	8	6	+45	+4	90	85	+	+	Diffuse enlargement	No change.	++	++	Tires easily. Otherwise fine
26. IR.	♀	18	Loss of wt. Night sweats.	6	8	+24	–9	130	120	+	+	Moderate enlargement Vascular	No change	+	+	Returned to work Gained 5 pds.
27. HL.	♀	35	Nervousness Tired and exhausted.	8	9	+27	–2	124	110	+	0	Moderate enlargement	Slightly smaller	0	0	Gained 15 pds Doing all work now Sleeps normally

GROUP 2.

CASE.	SEX	AGE.	Symptoms before treatment	DURATION OF TREATMENT IN MOS	NUMBER OF TREATMENTS	BASAL METABOLISM BEFORE	AFTER	PULSE BEFORE	AFTER	TREMOR BEFORE	AFTER	THYROID Before.	GLAND After.	EYE SIGNS BEFORE	AFTER	REMARKS.
1. N	♀	48	Moderate nervousness. Operated 2 yrs ago for exophthalmic goiter.	2	2	+13	−4	0	0	+	+	Slight Diffuse. Operative scar	No change	0	0	Somewhat improved. Has symptoms not due to thyroid.
2. VA.	♀	24	Weakness and palpitation persisting after thyroidectomy 1½ yrs ago	1	2	+42	+21	105	100	+	−	Small, diffuse Operative scar	No change	+	+	No marked improvement except that which occured before treatment
3. EP.	♀	28	Loss of wt. Palpitation. Nervousness	11	11	+39	+10	100	100	0	0	No palpable gland Operative scar.	No change	++	++	Is stronger. Can do work. Palpitation diminished.
4. ML.	♀	30	Shortness of breath. Weakness. Palpitation.	5	6	+22	+15	+	0	+	+	Small, diffuse Operative scar.	No change.	++	+	Improvement not marked
5. ES.	♀	52	Weakness. Loss of wt. Operated 10 yrs ago.	2	3	+20	+15	110	−	+	+	Small, diffuse.	No change.	++++	++++	Says she feels better.
6. EA.	♀	27	Nervousness, weakness. Palpable gland since 15 yrs of age. Lobectomy [illegible] 1919	2	2	+28	+24	96	100	−	−	Thyroid barely palpable. Operative scar	No change	+	+	Has early progressive polyarthritis. No marked improvement

GROUP 3.

CASE.	SEX	AGE.	Symptoms before treatment	DURATION OF TREATMENT IN MOS	NUMBER OF TREATMENTS	BASAL METABOLISM BEFORE	AFTER	PULSE BEFORE	AFTER	TREMOR BEFORE	AFTER	THYROID Before.	GLAND After.	EYE SIGNS BEFORE	AFTER	REMARKS.
1. HO.	♀	38	Weakness [illegible] yrs. Constipation. Palpitation. Operated 1920	2	2	+25	+30	104	100	−	−	Adenomatous [illegible]	No change	−	−	10 days after lobectomy BMR was same.
2. BW.	♀	31	Dizziness, weakness, nervousness. [illegible]	1	2	+36	+33	90	90	+	+	Adenomatous [illegible]	No change	+	0	No improvement noted.
3. PL	♀	35	Exhaustion. Nervousness. Increase in size [illegible]	2	4	+27	+21	114	95	+	±	Diffuse enlargement. Two adenomas palpable	No change	0	0	No marked improvement

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rate of plus 65 per cent. This type of case has generally been given to the surgical service, but it was agreed because of the severity of the nervous manifestations to try rest in bed and *x*-ray therapy first. Two weeks after her first *x*-ray treatment her rate had fallen to plus 25 per cent and the pulse had decreased from 120 to 90. Subjectively she was greatly improved and the insomnia had disappeared. Three weeks following her second treatment the basal metabolic rate had dropped to plus 18 per cent. This case received from the first 34 milliampere-minutes of radiation. This case has not been completed and is discussed to show the results of more intensive therapy.

Group 2 consists of 6 cases which had partial thyroidectomy but in whom hyperthyroidism was present. All of these cases had an increased basal metabolism. In Case 3 of this group the improvement has been sufficient to enable the patient to resume work. In the other 5 cases the improvement has not been as marked as the decrease in metabolic rate from plus 27 per cent before to plus 13 per cent after therapy would indicate. The subjective symptoms have shown little or no improvement.

Group 3, measured both clinically and by basal metabolic rate showed no response to *x*-ray therapy, conforming quite generally to accepted ideas of cases of toxic adenoma. The average basal rate before treatment was plus 29 per cent and afterwards was plus 28 per cent.

DISCUSSION IN GENERAL

We wish to mention a few cases that are incomplete and are not included in our series of 35 cases. A woman of twenty-seven was operated recently after being under incomplete observation for a period of a year. She has had 4 treatments during the last ten months, usually with intervals of from two to three months. At the beginning her basal rate was plus 35 per cent. Two months ago, on entrance to the hospital, she had a rate of plus 13 per cent. The patient wished an operation solely because of the enlargement of the thyroid. Subjectively her symptoms had disappeared, and objectively exophthalmos and enlargement of the neck were the only remaining signs of hyperthyroidism. On consultation the surgeon felt that she might possibly have an adenoma in the region of

the isthmus, and thought for that reason operation was indicated. At operation she was found to have only an enlarged goiter of the hyperplastic type. The surgeon states that the operation was not more difficult than on the

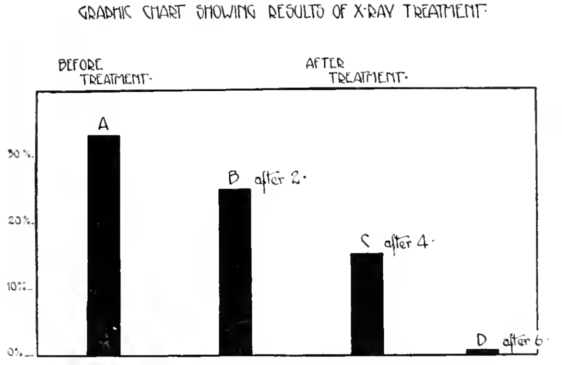

Fig. 1. Diagram showing average metabolism levels after X-ray treatment. Column A represents percentage increase before treatment.
" B - the average after 2 treatments.
" C - the average after 4 treatments.
" D - the average after 6 treatments.
This chart includes the cases from Group 1 only.
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usual untreated thyroid. This is in direct accord with Porter's observation in Boston in correlation with Means' and Aub's work. Rave, from the European side, also states that he can find no greater difficulty in the removal of thyroids which have been subjected to x-ray therapy than in untreated cases. To return to Case 17 mentioned above, which did not respond to x-ray therapy, it was found at operation that the gland was somewhat more difficult to remove than in the usual case.

One other case, which is incomplete, is to be mentioned. A young girl, aged twenty, entered the hospital with a basal metabolic rate of plus 65 per cent and was give a preliminary x-ray treatment and put to bed. Two weeks later her basal rate was plus 43 per cent with a corresponding clinical improvement. An acute tonsillitis with peritonsillar abscess developed at this time and for several weeks x-ray treatment was discontinued. After removal of the tonsils under local anesthesia her basal metabolism was found to be plus 80 per cent. At this time she insisted on returning home, and two weeks later was operated upon at another hospital, dying during the operation. This case is mentioned because we felt that her increasing rate made surgery inadvisable at that time. As is stated by Means and Aub in their work of 1919, "a progressively increasing basal rate is a contraindication to operation." Another case, which left the hospital against advice immediately following the first x-ray treatment, died two and a half weeks later, appar-

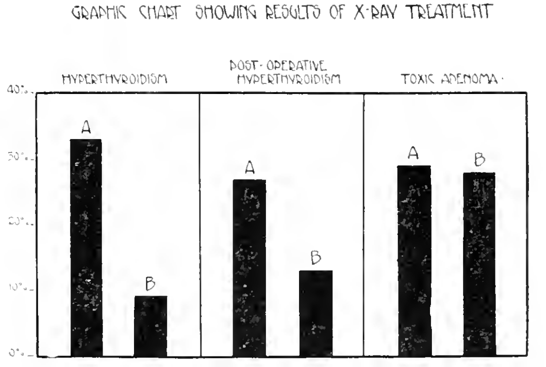

Fig. 2. Diagram showing average metabolism levels in the three groups of cases under discussion. A - before X-ray treatment. B - after X-ray treatment.
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ently from an acute thyrotoxicosis. He entered the hospital markedly febrile, extremely fast pulse, tremor and exophthalmos. His basal metabolic rate on entrance was plus 80 per cent. After six weeks' rest in bed he showed no improvement except for a fall in his basal metabolic rate to plus 54 per cent. An x-ray treatment was administered at this time and on the following day the patient insisted on returning home. A communication from his physician states that he died two and a half weeks later from hyperthyroidism. All other cases have been checked and we now know the condition of the patients in this series at this time. Not one has had a relapse.

Improvement as a rule begins about two weeks after the first treatment; first as a marked subjective response, later as an improvement in the objective findings. The earliest symptoms to disappear are usually tremor, nervousness, insomnia and subjective cardiac disturbances, the latter even if the pulse rate is not materially diminished. In the more severe cases improvement usually comes about more slowly and is first noticeable after the second and third treatments.

In all of the cases, improvement has continued for many months after the last x-ray treatment. This improvement is at a time when the basal rate is nearly normal, the basal rate being used at this time only as a

mathematical check upon our patients. We have not attempted at any time to get a minus rate, thereby removing the probability of myxedema occurring. There are two cases in this series where the gland has gradually decreased in size. Exophthalmos has decreased in a few, but in none, at this early date, has it entirely disappeared. Tachycardia has been usually the last symptom to show improvement, and, as must be emphasized, most patients have for a long time retained a tendency to an unstable pulse during periods of unusual stress. This experience is in accord with those treated surgically; improvement is often slow and is only complete after months or even years.

It is known that in severe cases of Basedow's disease enlargement of the thymus is frequently found. Cappele and Bayer[7, 8] have reported a few such cases where the thyroid was nearly normal in size, and where after thymus removal symptoms have disappeared. Nordentoft reports numerous cases where only after radiation of the thymus as well as the thyroid was improvement noted. Also he reports a few cases where radiation over the thymus alone gave marked improvement but not a complete cure. This may account for some of the early failures in the *x*-ray treatment of this disease, as formerly most roentgen therapists did not include the thymus in the area treated. The routine inclusion of the thymus may account in some degree at least for the better and more lasting results obtained today.

SUMMARY

1. Of 27 cases of Graves' disease without complications, who were subjected to *x*-ray treatment, but were not operated, 24 are well, both from the clinical and laboratory standpoint. The treatment has been complete for nearly eight months. The remaining 3 cases came to operation. Of these three, one, we feel, was definitely improved before operation, the other 2 were normal a few months after operation. Of 6 cases of post-operative hyperthyroidism, which had relapsed, one showed a definite cure. The other 5 showed no improvement. Of 3 cases of thyrotoxic adenoma none showed any response to *x*-ray therapy.

2. The only case of our series which was operated during an increasing basal metabolic rate died an operative death.

3. We feel that the results obtained in the earlier cases might have been attained more quickly if more intensive therapy had been used.

4. No bad results or complications, which we could attribute to the treatment, have occurred in any of our series.

5. From our experience with this treatment we are firmly convinced that, only with the closest possible cooperation between the clinician and roentgen therapist, can satisfactory results be obtained.

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REPORT OF TWO INTERESTING CASES OF GENITO-URINARY PATHOLOGY

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The two cases reported below are interesting from the standpoint of the roentgen-ray findings.

Both cases were sent to the New York Diagnostic Clinics for diagnosis, and the conditions found upon roentgenographic examination are as shown in the illustrations accompanying this article.

CASE I

Chief Complaint. Swelling in the left testicle, penis, back and leg for several years.

Family History. Father died of apoplexy at the age of fifty-five. Mother is alive and well at fifty-nine. One sister died at nineteen from childbirth. There are two sisters alive and well.

Past History. Diphtheria at ten, whooping cough at eight. The patient had bladder operated at the age of twelve, and two stones were removed. He was sick in bed four weeks at this time. No gonorrhea or lues.

Habits. Appetite, fair; bowels, regular; sleeps well. Weight: patient lost 17 pounds in about eight months. Urination:no micturia; voids about four or five times during the day; no pain. Smokes twenty cigarettes per day.

Present Illness. Patient was in good health except for a few mild colds until 1912 when, during the summer, he developed a swelling in the left testicle. This came without any apparent cause, no injury nor violent exercise nor infection. The swelling gradually increased and the pain extended down the left leg. The patient was confined to bed for one week. He made a perfect recovery. There was no urethral discharge. In July, 1916, he had a second attack which also lasted one week but disappeared completely under local application. In May, 1920, the patient had a third attack in the left testicle and the swelling still continues. The pain is still present but is not so severe. The organ appears very hot and very sensitive to the touch.

One month after the last attack the right testicle became similarly involved and has remained about one and one half times the original size. About one month ago the pain extended down the left leg, across the hip and into the groin. The patient feels better when at rest.

Fig. 1. Case 1. Calculus in right ureter.

On October 12, 1920, the patient was operated in St. James Hospital, Newark, and the vein was removed from left testicle. He was in the hospital two weeks and home four weeks, feeling quite well until he suffered another attack of severe pain about five weeks after his operation. Two months later he had another severe attack and for the first time had a thick, white, slimy discharge from the penis. He became very weak

and was in bed ten days. He then went to another physician and was told he might have a stone in the kidney.

Two weeks ago, while working in the office, he had another attack of severe pain in the left testicle, going up to the hip and down the leg to the knee and up to the lower

FIG. 2. Case I. Right kidney.

part of the back. This attack was so severe that it doubled him up "in a knot" and lasted four hours. The pain and intense soreness in the testicle are still present. The urine was examined and found to contain much pus. The patient was never roentgenographed and had no blood in the urine. (History taken January 28, 1921.)

Genito-Urinary Examination. Both epididymes are enlarged and tender. The enlargement is confined mainly to the body and globus minor. It is nodular to the touch. The cord on the left side is somewhat thickened, probably due to the recent operation.

On rectal examination the prostate is found to be indurated and slightly enlarged. On the left lobe there is a well-marked depression showing previous suppuration with subsequent cicatrization.

On abdominal palpation there is found to be some rigidity of the right rectus. Deep palpation elicits questionable tenderness over the right kidney and ureter down to the bladder.

Cystoscopy. The trigone is congested. The left ureter appears normal and admits a catheter to the renal pelvis. The right ureter shows a thickening, redness and edema. Thick pus is seen coming out in frequent squirts. The bladder wall over the right ureter is elevated, forming a definite mound-like bulging formation, which appearance indicates a stone in the intravesical portion of the ureter. The catheter could not be passed into the right ureter.

The urinalysis showed a heavy trace of albumin and pus. The urine from the left

FIG. 3. Case II.

kidney after ureteral catheterization was negative for tubercle bacilli. There were pus and red blood cells present. The phenolphthalein showed 55 per cent excretion at the end of one hour. The right ureter could not be catheterized. The Wasserman and G. C. were both negative.

X-Ray Findings. The right kidney is infiltrated with large, calcareous deposits, both in the pelvis and the parenchyma resembling a thorium injection. In the right ureter extending from the vesical junction to about the middle of the sacro-iliac articulation there is a large calculus resembling a cast. This is extraordinary in size, fully 5 inches long and 1 inch wide at its thickest portion.

Roentgenogram of the Teeth. The roentgen-ray examination of the teeth at that time showed a number of retained, infected roots and several abscesses present. Whether this was the original focus of infection it is impossible to say.

CASE II.

Chief Complaint. Burning sensation when urinating.

Family History. No kidney trouble.

Past History. Irrelevant.

Present Illness. Four weeks ago patient was operated on for right inguinal hernia and while recovering he began to have burning on completion of urination. At times he has had a stoppage of urine during the act. For a short time after the operation he had blood in the urine. He feels burning in the perineum but not at the head of the penis. When standing, the patient has to urinate every fifteen minutes, also from two to four times at night.

Cystoscopic Examination. The cystoscopic examination shows several inches of catheter curled up in the bladder and incrusted with urinary salts.

Urinalysis. The urine is very cloudy and contains much pus, albumin and many shreds.

Roentgen Findings. Coiled catheter in the vesical bladder.

DEVELOPMENTAL RESTS IN CECUM AND ASCENDING COLON AND THEIR ROENTGEN-RAY DIAGNOSIS*

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IN presenting this subject for Mr. Trahar and myself we wish it understood that we are not in any way claiming credit for anything new in medicine, but rather are emphasizing the importance of roentgen-ray methods in the diagnosis of conditions already well known to anatomists and surgeons.

The literature of medicine supplies abundant discussion of anomalies in the position of the cecum and ascending colon, but so far our search has not been rewarded by the discovery of any comprehensive discussion of roentgen-ray diagnosis of these conditions. Practically all reports are drawn from the autopsy and surgical reports.

As we say, the literature on the subject is voluminous. Not so much does that apply directly to the subject under discussion but rather as a side issue on that battle-ground of the learned surgeons for the past fifteen years, namely, the presence, the source, and the importance of the various bands found especially profusely in relation to the bowel in the right quadrant of the abdomen.

The subject was opened or reopened by the work of Lane. Soon a surgeon who had no particular type of intestinal band named after him could scarcely consider himself among the elect. The humor of the situation lies in the fact that this ground had all been covered by the anatomists long before and the bands described, the majority of them already bearing the names of the anatomists who did the work.

A very interesting and complete summary of the historical side of this subject is contained in an article by Samuel Clarke Harvey, entitled "Congenital Variations in the Peritoneal Relations of the Ascending Colon, Cecum, Appendix, and of the Terminal Ileum."[1]

It is not necessary, however, to go deeper into this phase of the subject as our primary interest in roentgen-ray diagnosis must be with posture and relationships, rather than with the type of supports. We can do no better in the discussion of the subject than to accept the classification of Harvey, adapted from Connells, in the changes of the cecum and colon in fetal life. Four main sub-divisions are made, namely: Migration, Rotation, Descent, and Fixation. Abnormalities in any of these developmental changes are described under the headings of (1) Deficient, or (2) Excessive.

It will be well at the outset, to review the embryological development of the parts in question. The works of Mall,[2] and later of Huntington,[3] on the anatomy of the peritoneum and abdominal organs, are standard, and we can do no better than to turn to an

NOTE. The designation, "immediate and twelve hour plates," refers to the practice in our laboratory of examining the patient first with a meal taken the night before, giving a study of motility and filling of the terminal ileum and cecum. This is usually followed by study of stomach filling. Roentgenograms taken at this time are designated as immediate and twelve hour plates.

*Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D.C., Sept. 27-30, 1921.

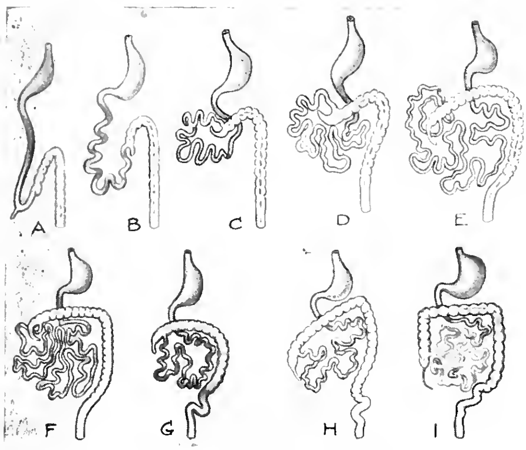

FIG. 1. The series of schematic figures illustrating stages in rotation of the intestinal canal.

illustration from the latter, for our summary.

In Figure 1 A, we take up the position of the stomach and intestines at approximately the fifth week of fetal life. The primitive gut here lies in the midline, is attached to the umbilicus, and the cecum is beginning to show as a bud on the caudal portion of the gut. Two factors are prominent in later changes; *first*, the relative rapidity of the growth of the different parts of the gut, and *second*, the relative size of the other organs, particularly the liver, to the body cavity.

As the liver at this stage rapidly increases in size, the bowel is pushed out of the coelom into the umbilicus. Here the rapidly growing small gut begins the forming of the primitive folds, while the large bowel is draped over it, in something approximating the later position. Next the relative increase in size of the body cavity permits the return of the gut. The small intestine is the first to return, and the large bowel follows, taking up the position shown in Figure 1 B, still later being pushed by the coils of small intestine into the upper right quadrant, Figures 1 C and D. Attention should be drawn to the fact that at this stage, the small intestine is entering from the right and above.

Rotation. The migration of the gut is now practically at an end. Figures 1 F and G illustrate the next change, that of rotation resulting in the entrance of the small bowel on the inner side, or from the left and below.

Descent and Fusion. The real growth of the cecum begins at this stage, and in the latter months of fetal life, and the first month after birth, the growth of the organ carries it and the ileocecal valve into the right lower quadrant, and the fusion of the various mesenteries results in its final posture, Figures 1 H and I.

It is well to note at this time that the descent and fusion are relatively late stages in the development cycle. Studies in comparative anatomy would indicate that fusion is doubtless a result of the assumption of the erect posture by mankind, and it is just to suppose that on the success of these last two processes, will depend to a considerable extent the ability of the bowel to function properly.

We are therefore, in Figure 2, calling attention to the normal fixed points in the bowel. The illustration is taken from Gray's "Anatomy."[4] Sections of the bowel retroperitoneal, or closely attached normally to the abdominal wall, are left, while those on a free mesentery are removed. The cecum and ascending colon are closely adherent to the wall.

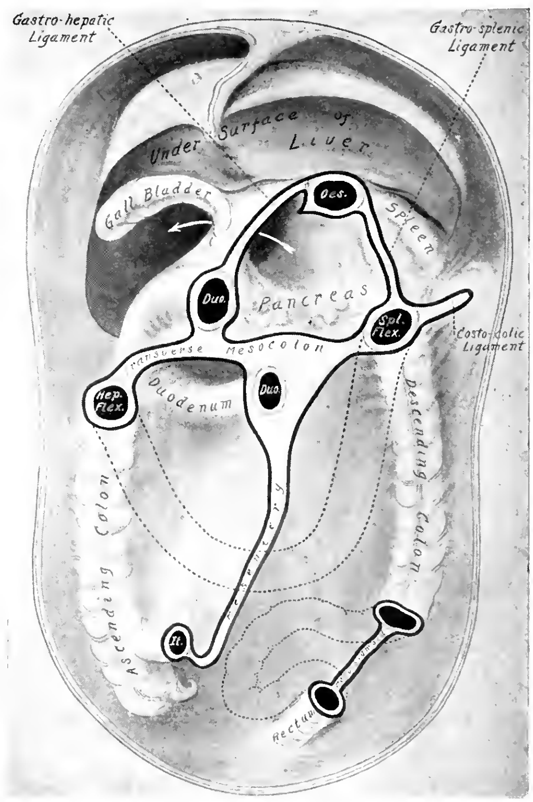

FIG. 2. Diagram illustrating position of normally fixed points of the bowel.

Normal Descent and Fusion. Figures 3 A and B are respectively the immediate and twelve hour plate, and the barium enema plate of what we consider to be a normal sthenic type in regard to descent and fusion of the cecum. We should state here that in this series of illustrations all immediate and twelve hour plates are taken standing, and the enema plates in a prone position, unless otherwise stated. We therefore are able in each case to judge the motility of the parts under the changed position. Figures 4 A and B are of a marked asthenic type of patient. The stomach lies in the true pelvis. In both of the above patients, the cecum appears to be normal in length, and the amount of movement is such that we would judge the supporting mesentery to be short.

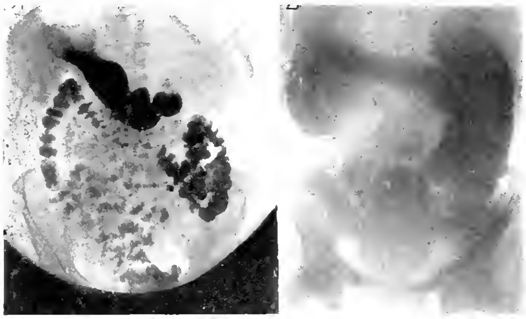

FIG. 3. *A.* Immediate and twelve hour roentgenogram illustrating normal descent and fusion of cecum in a sthenic patient. (Plate taken in erect position.) *B.* Barium enema of the same patient as shown in Fig. 3 *A*; normal motility of cecum. (Plate taken in prone position.)

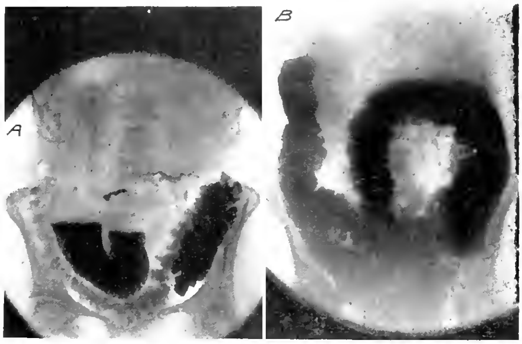

FIG. 4. *A.* Twelve hour roentgenogram illustrating normal descent fusion of cecum in asthenic type. (Plate taken in erect position.) *B.* Barium enema of same patient as shown in Fig. 3 *A*, illustrating normal motility of cecum. (Plate taken in prone position.)

Familiar Type, Excessive Descent of Cecum. In Figures 5 and 6, attention is called to the similarity in general conformation and especially in cecal descent in a young woman (Figure 5) and her mother, Figure 6. In the two cases there is an almost identical excessive descent of the cecum. The enema in the mother's case, Figure 6 B, shows moderate motility.

Excessive descent of the cecum is almost as common in the sthenic type as in the asthenic. This is particularly true in women. Figure 7 is an example of such a case. The stomach and bowel are in good position and

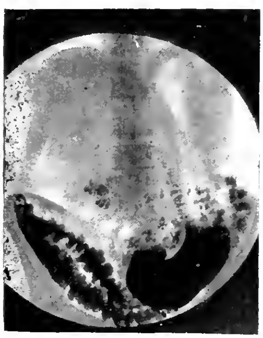

FIG. 5. Immediate and twelve hour roentgenogram showing excessive descent of cecum in young woman of asthenic type. (Plate taken in erect position.)

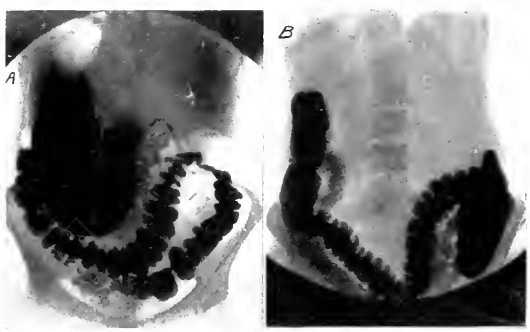

FIG. 6. *A.* Immediate and twelve hour roentgenogram of mother of patient shown in Fig. 5, illustrating similar types in members of same family. (Plate taken in erect position.) *B.* Enema plate of patient shown in Fig. 6 *A*, showing moderate degree of motility of cecum. (Plate taken in prone position.)

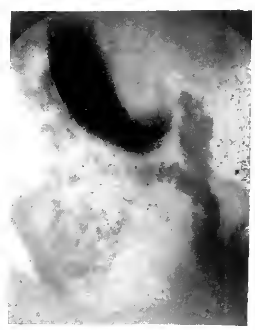

FIG. 7. Immediate and twelve hour roentgenogram illustrating excessive descent of cecum in patient of otherwise sthenic habitus. (Plate taken in erect position.)

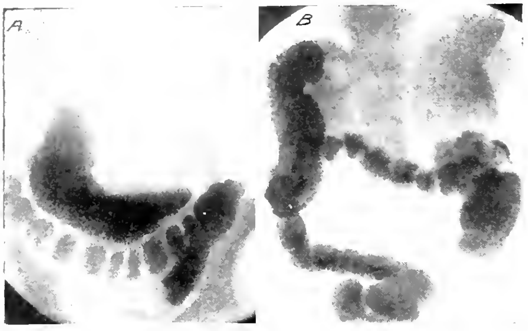

FIG. 8. *A*. Immediate and twelve hour roentgenogram of sthenic type showing abnormal motility of cecum. (Plate taken in erect position.) *B*. Enema plate of patient shown in Fig. 8 *A*, showing abnormal motility of cecum. (Plate taken in prone position.)

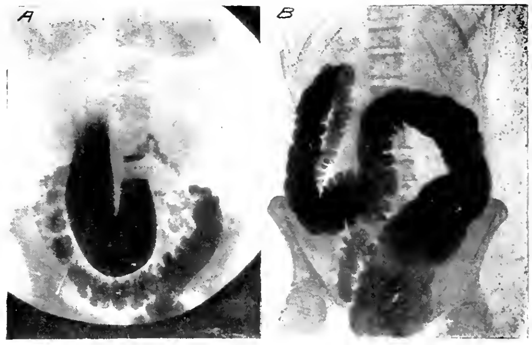

FIG. 11. *A*. Immediate and twelve hour roentgenogram showing moderate motility of cecum and extreme motility of hepatic angle of colon in an asthenic patient. (Plate taken in erect position.) *B*. Enema plate of same patient showing extreme motility of hepatic angle. (Plate taken in prone position.)

FIG. 9. *A*. Immediate and twelve hour roentgenogram of a sthenic patient showing abnormal motility of cecum. (Plate taken in erect position.) *B*. Enema plate of a sthenic patient shown in Fig. 9 *A*, showing abnormal motility of cecum. (Plate taken in prone position.)

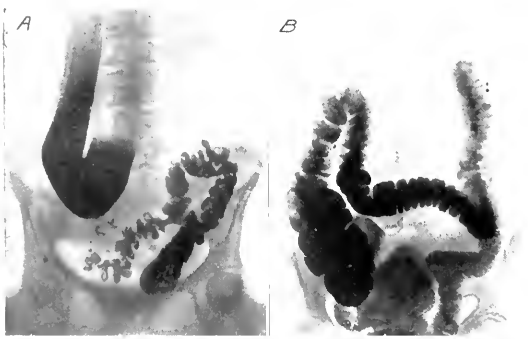

FIG. 10. *A*. Immediate and twelve hour roentgenogram showing moderate motility of cecum and extreme motility of hepatic angle of colon in a moderately asthenic patient. (Plate taken in erect position.) *B*. Enema plate of same patient showing extreme motility of hepatic angle. (Plate taken in prone position.)

the tone is good, while the cecum extends to the true pelvis. Our experience would indicate that such a cecum predisposes to imperfect bowel function.

Abnormal Motility of Cecum and Hepatic Angle of Colon. The roentgen-ray evidence of deficiency in fusion must be in terms of motility of the parts. Figure 8 A is the immediate and twelve hour plate of a sthenic patient. Comparison with the enema plate,

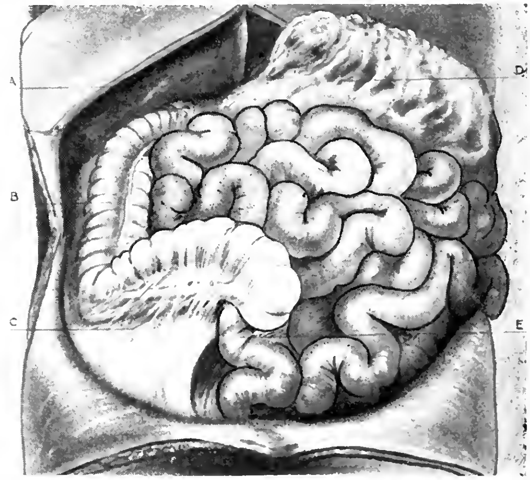

FIG. 12. Adult human subject with non-rotating cecum, the ileum entering the large intestine from the right and behind, and the appendix placed to the right of the ascending colon. (From a fresh dissection.) (Huntington's Anatomy of the Peritoneum and Abdomen.)

A, Liver. *B*, Ascending colon. *C*, Appendix adherent to lateral aspect of ascending colon and to ileac parietal peritoneum. *D*, Great omentum. *E* Terminal ileum.

FIG. 13. Strangulation and resulting gangrene of cecum in portion of small intestine due to torsion at hepatic angle of poorly fused cecum; drawing from specimen removed at operation. (Coffey.)

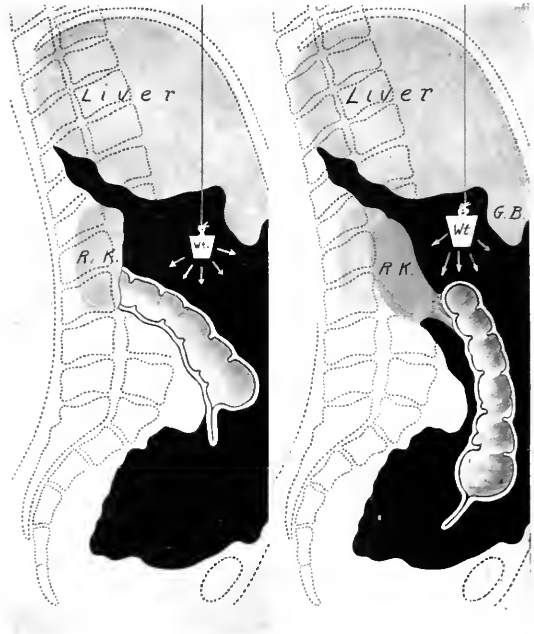

FIG. 14. *A*. Diagram showing direction and shelf of normal ascending colon. (Coffey.) *B*. Diagram showing mobile cecum seen where fusion is not complete, also its effect in displacing the right kidney to which it is attached. (Coffey)

Figure 8 B, shows a mobility of nearly five inches in a part that normally is on a very short mesentery. In Figures 9 A and B, we have a similar condition in an asthenic type of patient. We call your attention to the relative positions of the hepatic angles in each of these cases.

Fixed Cecum and Mobile Hepatic Angle. Figures 10 A and B; Figures 11 A and B are cases where the cecum is normal in mobility and the hepatic angle varies greatly in position. Here we must ask ourselves if the relative fixation of the cecum is a normal fusion, or due to secondary mechanical factors, such as bands. Evidence of such must be sought for.

Resultant Pathology. At this point it will be well to consider if these factors are or are not, within normal limits. We must do this not only on the basis of the mechanical, but also the functional results of variations in descent and fusion of the colon. Figure 12 is from Huntington's "Anatomy of the Peritoneum and Abdomen." He describes this as a non-rotated cecum with appendix adherent and to the right. To us this appears rather as a deficiency in fusion of the cecum with bands and retrocecal appendix. The mechanical pathology latent in such a condition is evidenced in Figure 13, from a drawing of the specimen, removed at an operation some years ago by Dr. Coffey. Here there has been an almost complete rotation of a poorly fused cecum with resultant blocking at the point of torsion and a gangrenous condition in the cecum and small bowel.

Figures 14 A and B, from Coffey's paper,[5] demonstrate the condition of unbalance resulting from excessive descent and non-fusion of the cecum. Spinal curves developed at the assumption of the erect posture give us the shelf on which the majority of the weight of the kidney and cecum is carried. With excessive descent or motility a condition of unbalance and of drag on attachments obtains.

Normally the mesentery at the hepatic angle extends well up and across the lower pole of the right kidney as shown in Figure 15 A. Figure 15 B shows the relationship in imperfect fusion. (Figures

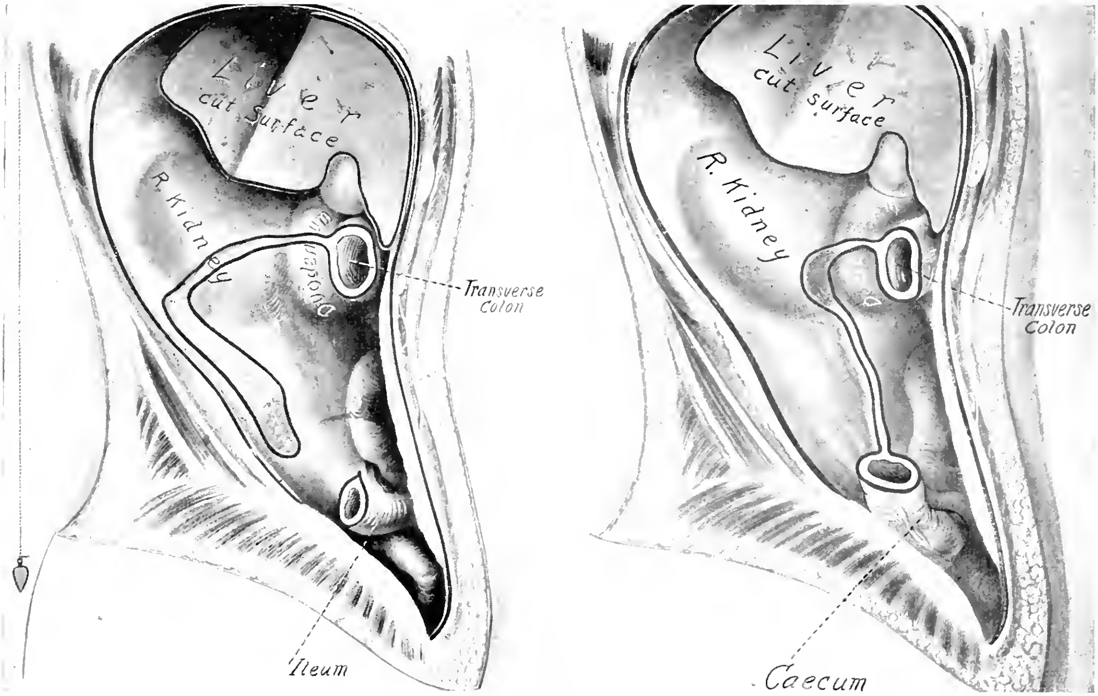

Fig. 15. *A*. Diagram showing normal position of an ascending colon across lower pole of right kidney. *B*. Diagram showing position of mesentery of ascending colon when rotation and fusion have been incomplete (cecum mobile); Goldthwait.

taken from an article by Dr. Joel E. Goldthwait.) Figure 16 is taken from a drawing illustrating the band which develops between the kidney and the hepatic angle in connection with this deficient fusion. The relation between this unbalanced pull of the above type of cecum and a ptotic right kidney is now generally recognized.

Fig. 16. Unfused cecum and ascending colon (cecum mobile, extreme case); Coffey.

We have purposely avoided the discussion of methods of fusion and of band formation. It seems logical to us, however, that whether bands result from irritational agents passing through the bowel wall or from fetal remnants, the presence of imperfect fusion and descent will increase functional difficulties in bowel clearing, and add to the opportunity of band formation or, in case of bands already present, will immeasurably add to their effectiveness as mischief makers. Figures 17 A and B illustrate well-known types of bands.

Abnormalities in Appendix. The development of the appendix is well under way when the cecal bud begins its descent. Figure 18 from Huntington shows abnormalities in the position and attachments of the appendix. Figure 19 from an article by Jackson, gives the relative position of the various types of retrocecal appendix in cross section.

Fig. 17. Illustrates well-known types of bands which sometimes accompany mobile cecum. (Coffey.)

Bland-Sutton in an article on "Misplaced and Missing Organs,"[6] says:

"In many cases in which the appendix lies vertically behind the cecum, its tip is firmly fixed near the liver; thus it happens if the tip of the fetal appendix is anchored it cannot descend with the cecum into the iliac fossa, but the descending cecum gradually lengthens the appendix. This will explain the fact that a retrocecal appendix is often abnormally straight and lacks a mesentery. Occasionally I have found the tip of a retrocecal appendix so firmly fixed to the peritoneum in the loin, that the cecum, though it has descended into the iliac fossa, has had its blind end turned upwards toward the liver. In such a case the cecum is suspended by the appendix."

We have all observed such cases in roentgen-ray examinations, but perhaps the full meaning of the finding has not been brought home to us.

Non-Descended Cecum. Non-descended cecum is a condition well recognized in literature. In an article on "Persistent Developmental Anomalies of the Large Intestine with Especial Reference to the Ascending Colon and Cecum,"[7] Royale H. Fowler reports 4 such cases and summarizes 19 other cases recorded in modern literature. So far as we could determine none of these was diagnosed by roentgen-ray examination, all

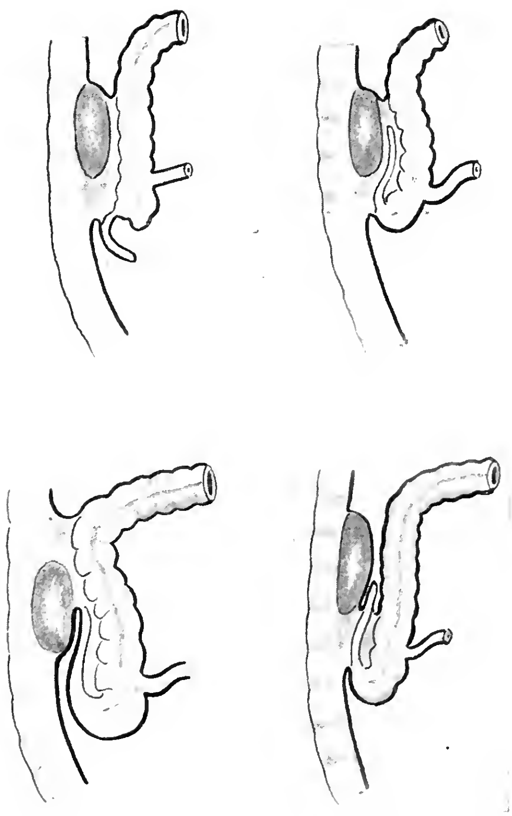

Fig. 18. Diagram showing abnormalities in position and location of appendix. (Huntington's "Anatomy of Peritoneum and Abdomen.")

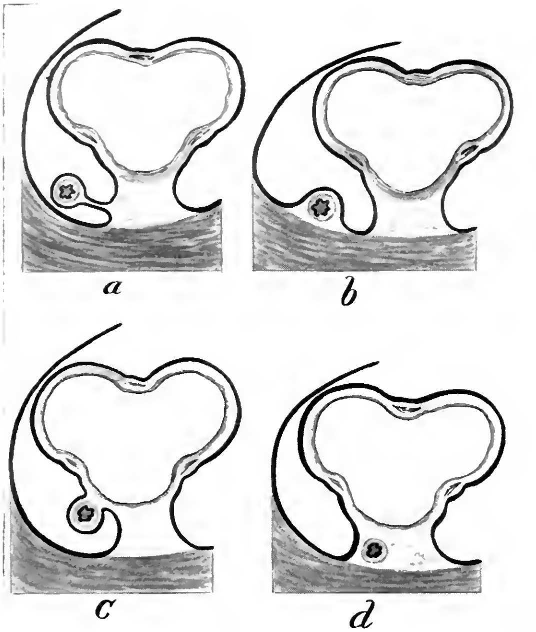

FIG. 19. Diagram showing relative position of the various types of retrocecal appendix in cross-section. (Jackson.)

being either surgical or autopsy reports. In Figure 20 from Hertwig, we again call your attention to the stage in embryological development represented in this abnormality. Figures 21 A and B give us the roentgen-ray findings of such a condition. The position of the tip of the cecum under the liver is characteristic. In the enema plate the position of the appendix is well shown and a loop of ileum beside it would indicate that the ileum was entering from above and to the right, therefore the cecum is probably non-rotated. Figures 22 A and B show the same condition in another patient. This latter case went to operation with the following surgical report: Case 9877. Operated by Dr. Coffey, April 20th, 1918. Operative findings: Unrotated cecum and ascending colon. The appendix and end of the cecum were well up under the right lobe of the liver. The cecum had not rotated so that the ileum entered from the right side and its mesentery was fused with the posterior parietal peritoneum, making a firm fixation. The lower portion of the ascending colon fell down towards the pelvis in the form of a loop; the upper portion of the ascending colon was drawn to the liver beside the appendix by a strong band at one place. The first part of the transverse colon had fallen down and adhered to the ascending colon, making a web.

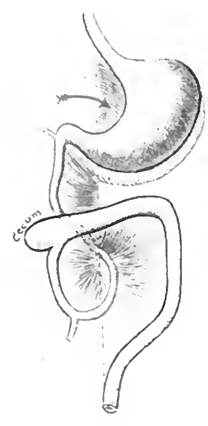

FIG. 20. Migration of the cecum. (Hertwig.)

FIG. 21. *A.* Immediate and twelve hour roentgenogram showing non-fused undescended cecum attached under the liver by appendix. *B.* Enema plate of same patient taken in prone position; position of appendix outlined.

Figure 23, from Huntington, illustrates very well the essential pathology of the above two cases.

Deficient Migration, Non-Fused, Non-Rotated. Apparently in these cases the descent of the cecum is usually normal or excessive. Figure 24 shows a characteristic appearance of the condition with the cecum hanging on the left from the splenic angle, the loops of

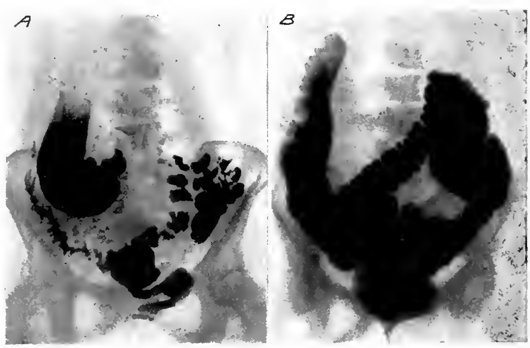

FIG. 22. Non-rotated cecum and ascending colon fusion by means of banding of ileum, and of first portion of transverse colon. (Characteristic loop formation.)

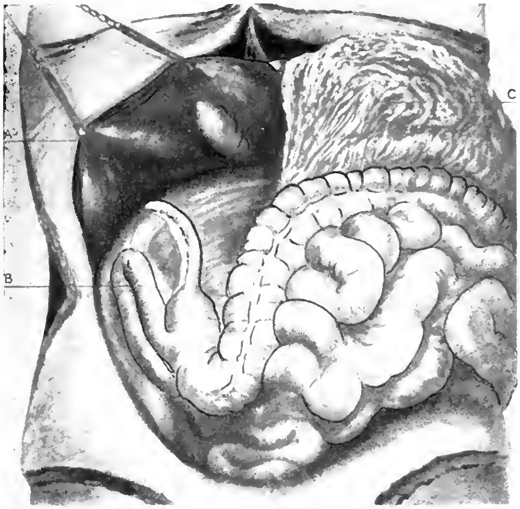

FIG. 23. Adult human subject with non-rotated cecum. The terminal ileum turns caudat from right to left to enter ileum. (Huntington's "Anatomy of Peritoneum and Abdomen.")
A, Liver. *B*, Terminal ileum. *C*, Great omentum.

ileum lying to the right and the ileocecal valve on the right. This first case was unique in that in addition to the usual constipation and toxemia, he presented a history of nocturnal epilepsy.

In the second case, Figure 25 A shows the immediate and twelve hour plate, Figure 25 B the barium enema erect and Figure 25 C the barium enema in the prone position. Again the ileum appears on the right and the free swing of the non-fused cecum is evidenced.

The third case in the series was complicated by the presence of a stomach ulcer; Figure 26 A is from the immediate and twelve hour plate; Figure 26 B from a similar plate on re-examination; Figure 26 C from the six hour and Figure 26 D from the barium enema plate. The relative position of the cecum and ileum is particularly well shown in the last plate. Case 523. Operative findings

FIG. 24. Immediate and twelve hour roentgenogram showing non-fused, non-rotated cecum with deficient migration.

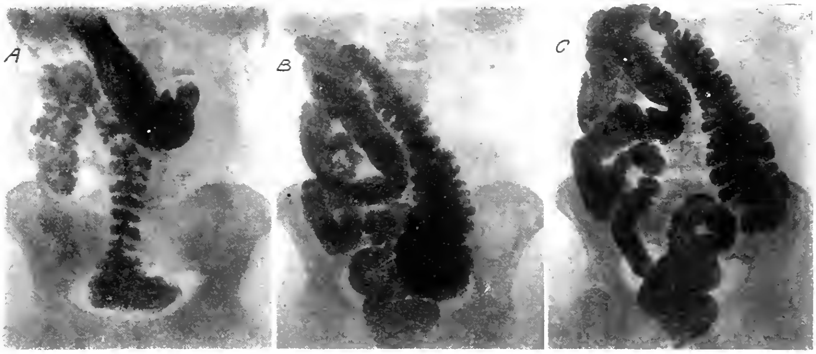

FIG. 25. *A*. Immediate and twelve hour roentgenogram showing second case of non-fused, non-rotated cecum, with deficient migration. *B*. Enema plate of same patient taken in erect position. *C*. Enema plate of same patient taken in prone position.

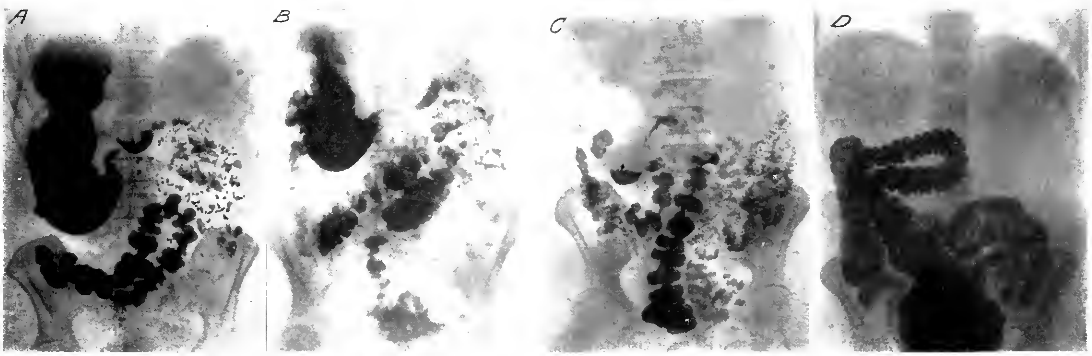

FIG. 26. *A*. Immediate and twelve hour roentgenogram showing third case of non-fused, non-rotated cecum with deficient migration. (Plate taken with patient in erect position.) *B*. Immediate and twelve hour plate of same patient on re-examination. (Plate taken in erect position.) *C*. Six hour roentgenogram of same patient. *D*. Barium enema plate of same patient. (Plate taken in prone position.)

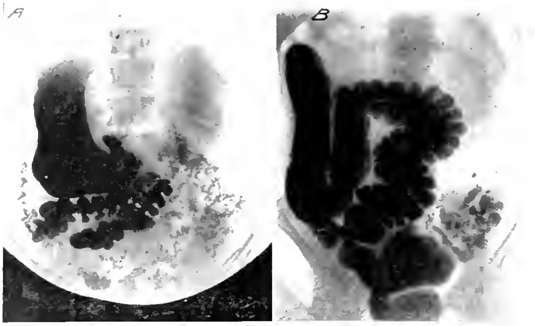

FIG. 27. *A*. Immediate and twelve hour roentgenogram of fourth case of non-fused, non-rotated cecum with deficient migration. (Plate taken with patient in erect position.) *B*. Barium enema plate of same case. (Plate taken in prone position.)

by Dr. Coffey, January 19th, 1918: Deep penetrating ulcer high up on lesser curvature; a thickening and spasm of the last two inches of the stomach; complete mobility of the cecum, ascending and transverse colon; the third portion of the duodenum had a mesentery and ran down the right side of the abdomen to a point below the end of the cecum as noticed in quadrupeds. A

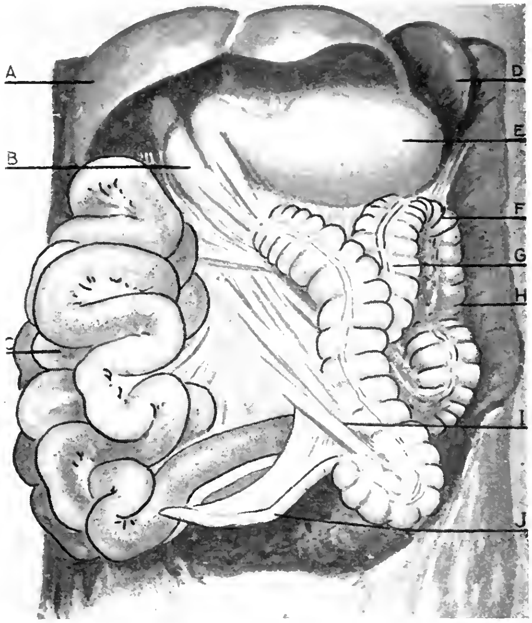

FIG. 29. Abdominal viscera of adult human female, in a case of arrested rotation of the intestines. (Columbia University Museum, Study on Collections.)

A, Liver. *B*, Duodenum. *C*, Small intestine. *D*, Spleen. *E*, Stomach. *F*, Splenic flexure. *G*, Responding to transverse colon. *H*, Ascending colon. I, Ileocolic junction. *J*, Appendix.

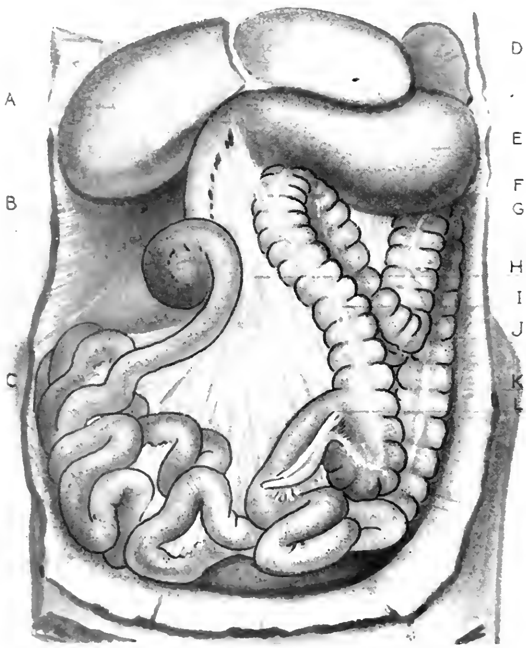

FIG. 28. Abdominal viscera of adult human male, nonrotation of intestine. (Columbia University Museum, Study on Collections.)

A, Liver. *B*, Duodenum. *C*, Small intestine. *D*, Spleen. *E*, Stomach. *F*, Bend of colon corresponding to hepatic flexure. *G*, Splenic flexure. *H*, Duodenocolic isthmus. *I*, Ascending colon. *J*, Irregular transverse colon. *K*, Descending colon. *L*, Ileocolic junction.

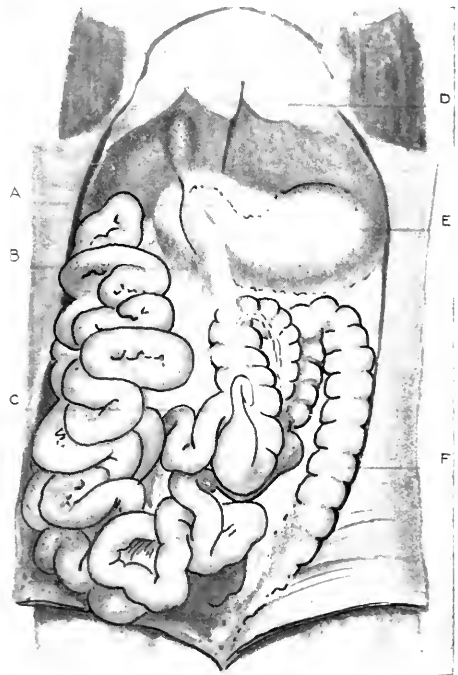

FIG. 30 Abdominal viscera of child of two years. Non-rotation of intestines. (Columbia University Museum, Study on Collections.)

A, Pylorus. *B*, Duodenum. *C*, Ileocolic junction. *D*, Liver. *E*, Stomach. *F*, Descending colon.

fourth case is shown in Figures 27 A and B, these being of the immediate and twelve hour and barium enema plates. Case 4969. Operated by Dr. Coffey, Feb. 5th, 1920. Operative findings: Spastic contraction of the duodenum about four inches outside the pylorus; cecum and transverse colon found to the left of the median line. Transverse colon attached to the pelvic wall below the sigmoid cecum with diseased appendix far down to the left side of the pelvis. A case of non-rotation and no parietal fusion on the right side. Duodenum had a mesentery that ran down to the right of the mesocolon; entire small intestine to the right of the ascending colon.

Figure 28 shows a drawing from Huntington illustrating the position of the bowel in cases similar to the above four. We note here the exposed condition of the duodenum. Figure 29 shows a similar case with bands causing angulation of the duodenum. Figure 30 might well represent the position of the appendix in a case reported by Lyas.[8] In this case the appendix was imbedded in the abdominal wall near the umbilicus. There was a fan-shaped mesentery with stump of old attachments above and to the right of the pubic arch. Appeared to be a congenital condition. The cecum was suspended in the abdominal cavity and the intestines strangulated between the appendix and the abdominal wall.

Other cases of the various types are recorded in our files. The above have been selected because of the more complete data, especially in the line of roentgen-ray evidence in the making of the diagnosis. The more primitive types of fetal rests demand the most careful surgery to give any benefit to the patient, and any surgeon will be most grateful to the roentgenologist who informs him of the general conditions to be met before the abdomen is opened. This is undoubtedly true in the bizarre, extreme conditions, but we wish to emphasize that it is the responsibility of the roentgen-ray diagnostician to evaluate the extent of importance of the findings in the less extreme cases, or at least to present the evidence to the clinician for his consideration in the final judgment of the case.

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THE ROENTGENOLOGICAL ASPECT OF SPRENGEL'S DEFORMITY*

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A PECULIAR deformity of the shoulder region occurring infrequently has been reported in the medical literature at intervals. The wider use of roentgen-ray diagnosis in recent years has served to reveal numerous instances of this condition and the lesion is no longer regarded as of extreme rarity. The deformity consists of a unilateral or bilateral elevation of the shoulder with or without osseous changes and is due to a congenital mal-development of the structures in one or both shoulders and the region of the base of the neck and upper posterior thorax.

The essayist has personally encountered 7 cases and knows of three other children who have this deformity. Three of the 8 cases investigated are illustrated in this presentation. The earliest report of congenital elevation of the shoulder seems to have been made by McBurney and Sands in 1888, but the description of Sprengel in 1891 has attracted most attention and, as a consequence, his name has most often been attached to the lesion. Joachimsthadl, in 1900, reported 3 cases. Several other observers have added cases of their own to the literature on this congenital malformation. The literature contains considerably more than 100 cases. Undoubtedly an increasing number will be added to the list in the near future due to a greater familiarity with the details of the deformity by roentgenologists, pediatrists, orthopedists and others.

The lesion undoubtedly begins early in the life of the fetus as there is so frequently an alteration of bony growth from the central axis outward of the early embryonic structures. In several instances, this change is more or less confined to the bones of the spine and neighboring portions of the ribs, although a few cases had no bone alteration at all. An upset in the evolution of the individual cells of the mesoblastic order results in the features now recognized and referred to under the title here given. It seems most plausible to regard this faulty anatomy as a temporary departure from the normal development of the structures in the shoulder region, after which temporary derangement a restoration of the normal growth of the cells is re-established. The embryonic enfolding then progresses to a normal conclusion, no additional defects taking place. By some observers it is believed that, owing to some mechanical factor, such as posture of the mother, the developing fetus is moved out of normal position, resulting in one or both arms being placed behind instead of in front of the body, as is normal.

The condition is not usually recognized at birth or in infancy (particularly the bilateral form), but when the child's wearing apparel is changed from baby clothes to dresses and suits, the parents notice that the neck seems shorter than it should be or that one shoulder is higher than its opposite. In practically all cases, there are no symptoms of any kind which would suggest that anything was wrong in the shoulder. In the first case that was referred to the writer for x-ray study on account of inequality of shoulders, the little girl's mother was considerably worried about the future date, when as a young lady, she would appear in evening gowns and low-necked dresses, at which time it would be revealed that she had shoulders of unequal height. This explains the descriptive terms of "Schoenheitsfehler" which may be translated into "beauty fault." In the case of one of the boys, the parents

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had not observed any particular difference in the two shoulders, but the boy came home crying one day because his playmates had said that he was "lop-sided." Another case was diagnosed as a "wry-neck" because the head was held a little to one side. In cases of bilateral involvement, the condition may not be noticed until the child reaches an age of from seven to twelve years.

Attention is sometimes directed to the shoulder because it is observed that in play, the child does not use one arm as much as the other, although both seem to be of the same size. Sometimes the arm on the affected side is found to be shorter than the opposite one, but this is relative rather than actual. Only occasionally the child will complain of a little pain or numbness which seems to extend down the arm, but this is quite the exception to the rule. In one case, the patient was not able to make as much use of the affected arm as the opposite one, as it tired easily, but no pain was experienced.

ROENTGENOLOGICAL ASPECTS

These cases are best studied by means of stereoscopic projections, which include the entire shoulder girdle, entire cervical vertebrae and upper half of the thorax. Some of these cases are missed by taking one shoulder only, there being no direct comparative shadows. Owing to the possible bony alteration which often accompanies this deformity, the patient should be placed in the supine position in order to obtain the greatest detail of the vertebral column, posterior ribs and scapulae.

Cases of congenital elevation of the shoulder may be divided into two main types: (*a*) simple, non-osseous alteration and (*b*) complicated, osseous mal-development. Each of these may be subdivided into (A) unilateral and (B) bilateral.

The simple type consists merely of an elevation in position of the scapula and related bones of the shoulder, there being no misshapen bones of spine, ribs, etc. In the simple type cases, not the slightest evidence of any bone alteration can be detected, there being merely a unilateral or bilateral high standing scapula. Obviously the latter type may be unrecognized, particularly if the elevation be slight.

The complicated type consists of elevation of the bones of the shoulder plus alteration of bone structures of the upper spine, ribs and shoulder. In the osseous, complicated type the bones most often involved are the lower cervical vertebrae (usually below the third), the upper four to six dorsal vertebrae, the ribs corresponding to these vertebrae and the scapula. Intrinsic changes of clavicle and humerus are seldom found.

In the cases of bone malformation there is a noticeable inconstancy of the individual bone alteration, no two cases presenting exactly the same anatomical changes. For example, in some instances, there may be found a fusion of two or more vertebral bodies; in other cases, there may be a spina bifida occulta; in still other cases, there may be an extensive osseo-anastomosis of the ribs on one or both sides. Each case seems to present an entirely new bone change. In one case, bilateral, though symmetrical, cervical ribs were present; in another case the first rib on one side was absent. Any one case may have a combination of several or perhaps all these features.

In all the cases there is a more or less marked elevation of the scapula on one or both sides. One may find that that portion of the scapular blade which lies above the base of the spinous process, is greatly in excess of the normal proportion, with a corresponding shortening of the inferior part of the blade. This results in a seeming, though not actual, sinking of the glenoid portion. Thus, the superior border of the scapula lies very much higher in the base of the neck than is normal. Frequently, the general configuration of the scapula gives the observer the impression of its being unusually small, particularly if the case be a unilateral deformity, the opposite normal serving by comparison to bring out the faulty outline of the affected bone. A marked scaphoid vertebral border of the scapula is sometimes observed, this edge be-

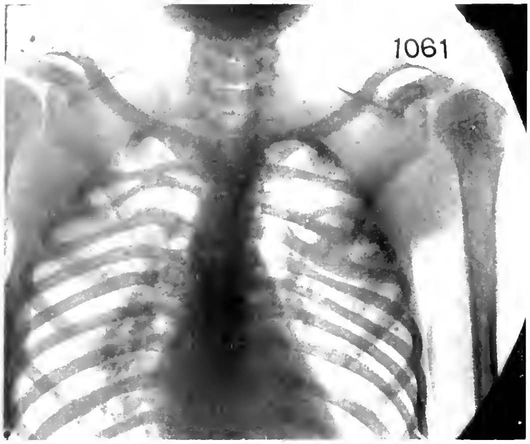

Fig. 1. Dr. Sill's case.

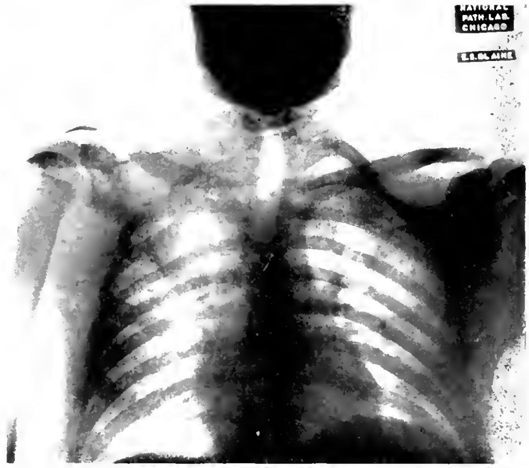

Fig. 2. Dr. Mueller's case.

Fig. 3. Dr. Moore's case.

ing almost crescentic in figure, with the inferior angle assuming a hook shape. In one of the cases this border appeared to be actually causing a pressure erosion of the posterior aspect of the underlying ribs and these ribs were narrowed almost to a point where it seemed that the slightest pressure on the thoracic cage would surely result in a fracture, but the child did not complain of the slightest degree of pain or discomfort.

In the cases observed, the roentgen-ray shadows reveal the usual degree of densities of normal bones, and the architecture of cancellous and cortical bone tissues are unchanged except at points of bone fusion and anastomosis. The varieties of rib osteo-anastomosis are many; in one case, four ribs were joined on superior and inferior borders in a synostosis for a distance along the bones of from 3 to 5 cm.; the fusion began about 3 cm. from the vertebral articulations. One case exhibits a sharp angulation of the uppermost dorsal spine due to a fusion and seeming collapse of the vertebral bodies. The interarticular facets may be entirely fused, thus obliterating these joints. Similar synarthrosis may also be found at the costovertebral joint. Sometimes, several of the laminar processes fail to unite, resulting in a spina bifida occulta; I have not observed a true spina bifida in any of these cases of congenital shoulder elevation. Most often it is found that the blade of the scapula, even if unaltered in configuration, is set more toward the anteroposterior position instead of lying transverse to the patient's body. This gives a marked prominence to the vertebral border of this bone (Fig. 4) presenting the so-called "winged scapula."

In almost all of the cases observed herein, there was found a limitation of abduction of the affected arm or arms, and an extraordinary ability to reach the arm posteriorly (Fig. 4) was a striking feature. In a

majority of these cases normal births took place and in those in which instrumentation was resorted to, there were no occurrences that would permit us to associate the deformity with the foreceps delivery.

Case I (Referred by Dr. Frederick Mueller). Girl, aged seven, white, American, normal delivery, well nourished and well developed physically and mentally. The head seems to set close on the body with unusually short neck. No complaint.

X-Ray Shadow Analysis. The left scapula lies much higher than normal and is considerably altered in outline, the superior portion being much in excess of the opposite bone, while the inferior portion is correspondingly shortened. The vertebral border is concentric in shape and appears to be eroding the ribs. The upper ribs (posteriorly) are altered in size and outline, there being an anastomosis between the second and third left ribs; the anterior portions of the ribs appear to be normal. The right scapula is also higher than normal but it is not misshapen. From the fourth cervical to the fifth dorsal spine there is mal-development of the vertebral bodies with slight deviation of normal spinal alignment.

Diagnosis. Case of congenital shoulder elevation (Sprengel's deformity): simple on left, complicated on right.

Case II (Referred by Dr. Frederick Mueller). Boy aged five, white, Polish, normal delivery, patient fairly well nourished, physical development good but left shoulder is higher than right.

X-Ray Shadow Analysis. A high position of the left scapula and shoulder. No bone alteration of spine, ribs, scapula, etc.

Diagnosis. Simple unilateral congenital elevation (Sprengel's deformity).

Case III (Cook County Hospital, Orthopedic Service, Dr. Henry Bascom Thomas). Boy, aged seven, white, Italian, normal birth, evidence of healed rickets, but is in good condition at this time. Has high right shoulder. Difference was noticed soon after birth but no attention paid to it at that time.

X-Ray Shadow Analysis. A high standing scapula on right, normal position on left; malformation of upper right ribs posteriorly. The laminar process of second to fourth dorsal failed to unite, though no spinous processes formed resulting in spina bifida occulta, there being no soft tissue tumor over same. Rudimentary cervical rib on left. (This latter variation is the only change found to involve the left side.)

Diagnosis. Unilateral, complicated, congenital elevation of right shoulder; unilateral congenital cervical rib of left side.

Case IV (Cook County Hospital, Children's Service; Dr. Julius H. Hess). Girl, aged one year and six months, white, American, foreceps delivery; sick child; no shoulder deformity noted; sent to *x*-ray department for examination of thorax, question of pneumonia.

X-Ray Shadow Analysis. The upper third of right lung field is occupied by a diffuse heavy shadow, probably consolidation of pneumonia. Additional findings: Both scapulae lie much higher than normal. Slight alteration of the upper ribs, posteriorly.

Diagnosis. Bilateral, complicated Sprengel's deformity; lobar pneumonia of upper right lung.

Case V (Referred by Dr. Grant W. Sill). Girl, aged eight, white, of well-to-do parents, family history negative for similar defects. Patient is of robust figure, well developed and well nourished. The neck is shorter than is normally proportionate. Patient makes no complaint of any kind. Her parents wish to know why her neck is so short. No history of injury or disease of spine (Fig. 1).

X-Ray Shadow Analysis. A bilateral elevation of the shoulders, faulty development of the lower cervical and upper dorsal spine, spina bifida occulta and rib osteo-anastomosis, no changes in the shoulder joints proper, both scapulae lie higher in relation to the

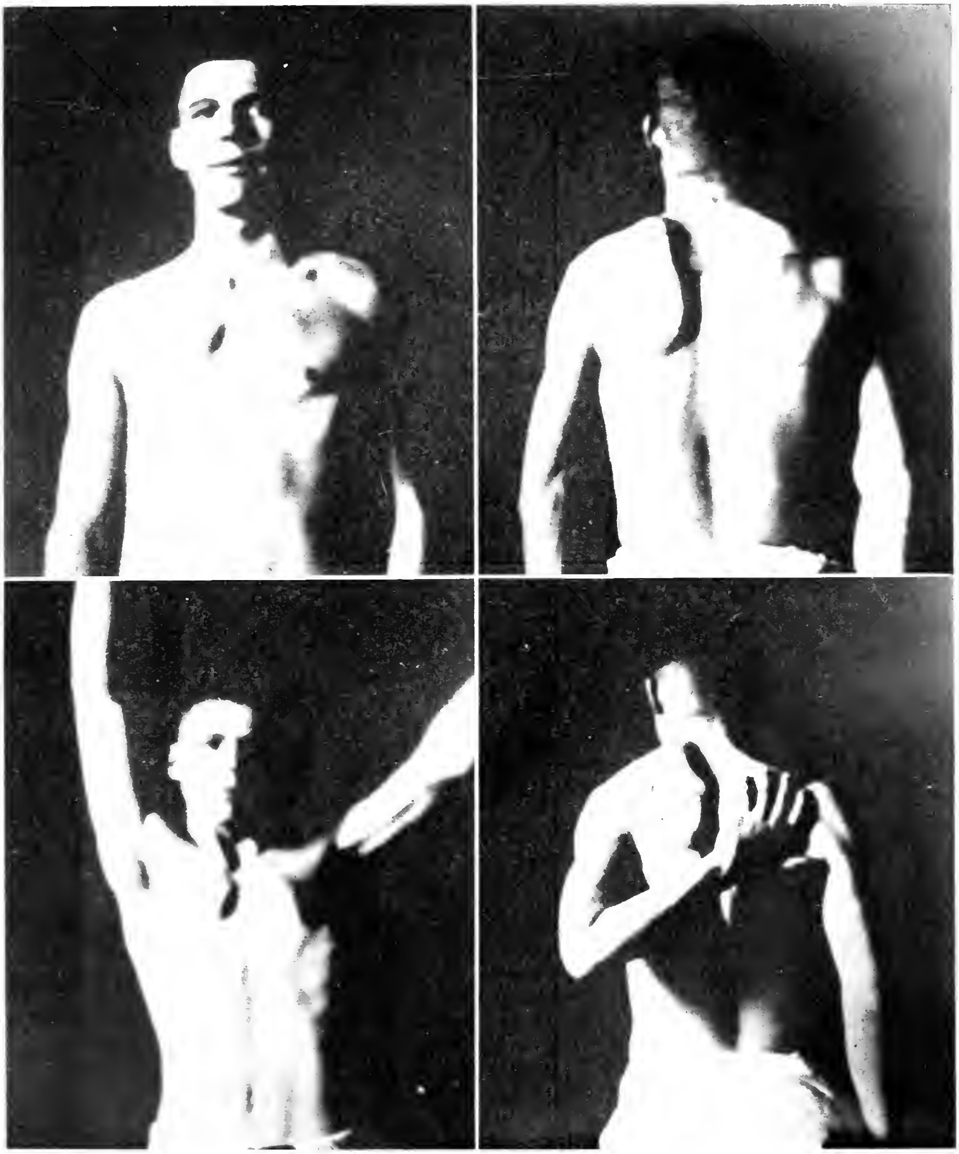

Fig. 3. Dr. Moore's case.

ribs than normal, literally filling the base of the neck.

Diagnosis. Congenital bilateral elevation of shoulders, complicated type.

Case VI (Referred by Dr. Frederick Mueller). A boy, aged eighteen, white, Jewish, normal physique, weight 118 lbs. No history of diseases or injury of the spine or shoulder. Has had children's diseases, "flu" and pleurisy. Says the right shoulder was always higher than the left as long as he can remember. Right arm tires easily. Sometimes drives his employer's automobile on long trips and finds that he has to do most of the steering with the left hand, as the grip of the right gets weak and numb. The right arm is carried higher than the left, which makes it appear shorter but there is no actual difference in the length of the arm (Fig.2).

X-Ray Shadow Analysis. The right scapula lies higher than the left. The bones of the left shoulder are normal; osteo-anastomosis of the second, third, and fourth ribs on the

right side; second degree cervical rib is found on the left side. The first rib on the right side is deformed. The scapula, clavicle and humerus are all unchanged; they merely occupy a higher position than normal. The sternoclavicular articulations appear normal.

Diagnosis. Unilateral congenital elevation of the shoulder, complicated type.

CASE VII (Referred by Dr. Beveridge H. Moore). A boy, aged seventeen, had fever in childhood but does not remember what it was called; the left shoulder is higher than the right; limitation of abduction of the left arm, can place palm of left hand flat on right scapula: posterior shoulder (Figs. 3 and 4).

X-Ray Shadow Analysis. A high position of the scapulae and shoulder but no bone changes whatsoever.

Diagnosis. Simple unilateral Sprengel's deformity.

A MODIFICATION OF TECHNIQUE FOR ROENTGENOGRAPHING UPPER MOLARS*

BY C. A. LE MASTER, D.D.S.
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JUST two factors enter into the production of a dental roentgenogram: proper technique, including exposure and development, and correct angle. While the first will be subject to the personal views and preferences of the individual roentgenologist, and may vary within considerable limits without in any manner impairing the diagnostic value of the roentgenogram, the latter, that is the angle of incident of the roentgen rays in relation to the film and the tooth, may not vary in the least without seriously detracting from the value of the roentgenogram.

The well-known law which governs this may be concisely stated: The angle of incident of the normal ray shall strike at right angle the plane which exactly bisects the angle formed between tooth and film—a law to which there is no exception.

In considering this rule, we readily learn the reason which renders the making of a roentgenogram of the upper molar area exceedingly difficult at times; namely, the shadow of the zygomatic arch and the lower margin of the maxillary sinus is often projected over the molar roots, a situation which occurs with annoying perversity precisely in those cases where a clear image of those roots is very important. Figures 1 and 2 illustrate this.

Various measures have been suggested to overcome this difficulty, all of which may be classified under one group—the deliberate producing of distortion, in such a manner as to throw the suspected area clear from these shadows. This, to be sure, will often furnish a roentgenogram of sufficient value, but unnately the relation of the various structures of the tooth appears at times distorted to a confusing extent. Rather than do this, a roentgenogram is very frequently taken in normal position and just as frequently some important diagnostic features are overlooked.

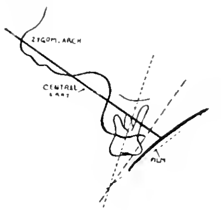

Fig. 1

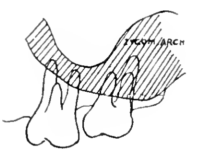

Fig. 2

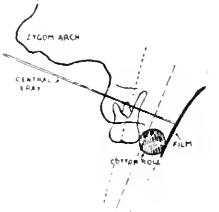

Fig. 3

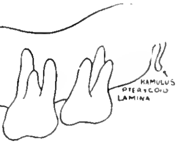

Fig. 4

In trying to find a method which will obviate this difficulty, I have come to the conclusion that it will have to be attempted, not by modifying the angle of incident of the

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*On account of the importance of this article it is published in its entirety.

roentgen rays, but by modifying the *angle of the film to the tooth*. Figures 3 and 4 illustrate the result of this procedure probably more easily than a lengthy explanation would. To sum up briefly: By placing the film into position approximately parallel to the long axis of the tooth to be examined, it will be possible to direct the roentgen rays below the zygomatic arch and antrum (maxillary sinus), entirely eliminating their overlapping shadows.

In practice this is done by attaching a medium-sized absorbent cotton roll to the lower edge of the film, and the patient is instructed to place his finger near the upper edge of the film, pressing it firmly against the palate. This will result in bringing the upper portion in close apposition to the apex of the roots, while the lower portion is removed from ½ to 1 cm. from the crown of the tooth. The apices of the roots are clear and free from superimposed shadows and yet in perfect proportion to the tooth itself and to the surrounding process.

X-RAY REPORT

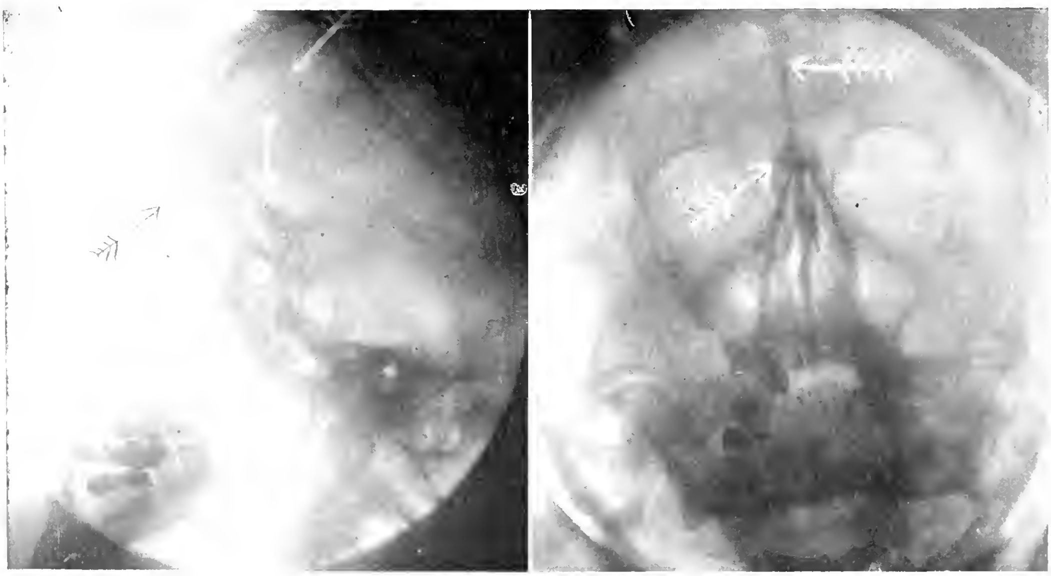
By J. S. YOUNG, M.D.

EAST ST. LOUIS, ILLINOIS

MRS. M. T. H., female, came to the hospital for treatment.

Clinical Diagnosis. Chronic headache and swelling of antrum.

X-Ray Report. Slight veiling of the left antrum. Marked calcified area in the median line just above and posterior to the frontal sinus. A dense round shadow lying in the median line possibly more in the right frontal sinus. Apparently increased ossification at this point. Deflected septum. Complete blocking of the ethmoids on the left side.



RADIUM COMBINED WITH X-RAY TREATMENT IN CARCINOMA OF THE BREAST*

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AT the request of your president I am presenting a subject similar to the one presented by me a year ago.[1] Dr. Douglas Quick has recently made an excellent review of the literature under a similar title and presents some very convincing evidence of the value of this treatment.[2] Boggs presented a paper on this subject before the midwinter meeting of the American Roentgen Ray Society, and you are all familiar with his excellent work.[3]

The treatment of carcinoma of the breast by radiation, whether by means of the roentgen rays or radium, is in principle the same as the treatment of malignant disease anywhere in the body. The success of the treatment is dependent upon (1) a clear recognition of the extent and nature of the disease, and (2) upon the most thorough and skillful application of the radiation to every portion of this malignant disease, for sufficient time and with sufficient intensity to destroy every malignant cell. The presentation of this substance under the above title is not intended to be an argument against any other method of treatment of malignant disease, nor is it intended that radiation shall replace surgery or any method that will successfully combat this dreaded disease. Much has been accomplished by surgery. Surely more has been accomplished by surgery than by any other means of treatment. More has been accomplished by surgery probably because that method of treatment has been more thoroughly developed, and has been in the hands of some of the most brilliant men in the world, and the greatest efforts of the greatest minds have been brought into activity for the development of that phase of treatment.

It is because of the failures that have so frequently occurred in the hands of the most skillful surgeons, and, at times under the most favorable circumstances, that the world is still hoping for something better. While radiation may not prove itself to be better, it should be our aim to develop the methods of application of radium to the same degree, with the same earnestness, the same enthusiasm and with the same hopefulness that have prompted our great surgeons. Toward this end, therefore, we as roentgenologists must not content ourselves with being simply technicians, but we must be students of pathology and of the causation as well as the nature of progression of malignant disease. We can then keep ever clearly in mind the likelihood of extension by metastasis, the direction that these metastases are likely to take, so that with our radiation we can completely surround the disease, for we can no more hope for success by treating a portion of the malignant disease than can the surgeon hope for success by cutting out a portion of it. If the disease has become universal, that is, if the disease has spread to various distant parts of the body, we cannot hope for complete and permanent success, though even in such advanced conditions we may hope for an arrest of the disease at times.

Both the roentgen rays and radium have in so many instances caused the complete disappearance of malignant disease in superficial places where it could be watched continually that most of the profession are today convinced more or less of their therapeutic value. Careful histological studies have been made of the tissues treated by these radiations so that we know today the microscopical changes that take place in the individual cells under their influence. The best review of this phase of the subject is that which has been made by Colwell and Russ.[4] One of the advantages of radiation over surgery is that it can be used more extensively and can be used especially to surround the growth. Radiation treatment, being for the most part painless, is more likely to appeal to the sufferer than is surgery. It is to be hoped that the elimination of fear of an operation will induce women as well as men

*Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6-7, 1921.

who suffer from this disease of the breast, to apply for treatment early and not do as is so common at present, when women conceal from their friends, and so far as possible from themselves, the knowledge of a tumor in the breast, until it causes severe suffering and until it has become almost hopeless so far as recovery is concerned. The very fact of this greater appeal places upon us a correspondingly great responsibility, first in making a careful diagnosis, in studying each case most thoroughly, and in obtaining consultation with surgeons, and assistance whenever possible; and second, the responsibility of using the greatest amount of skill in the most thorough manner at the earliest moment possible. It will surely appeal to anyone that more should be accomplished in the treatment of an early case than in one far advanced. In spite of this common sense view, all of us experience the most paradoxical position which is so often taken by surgeons who assume that the x-ray and radium are of no value and should not be used in an early case of malignant disease, while these same surgeons will hope for the most miraculous results after the disease has invaded the chest, the lungs and often the entire body, or has recurred after an operation and has been more or less dissipated through the system. I have frequently seen patients who have had their fears of recurrence appeased with the statement that they are suffering from rheumatism, and that the pains associated with recurrent disease are "healing pains," or if they happen to have had some x-ray treatment, the pains and even the recurrent infiltration of the tissues are explained by the statement that the x-rays produce such changes.

We are not in a position today to claim that radiation should replace surgery, probably because our technique and equipment are passing through a stage of rapid development, and the duration of our experiences is not sufficiently long to make a fair comparison with the results obtained by surgery. Still I believe that we can justly place the truth as nearly as possible before the patient, and allow the patient to choose the treatment most desired. In the hands of the best surgeons we have a right to expect a greater percentage of cures than in the hands of those less skillful and less experienced. Likewise in the hands of the most expert and best equipped roentgenologist we have a right to expect more satisfactory results than in the hands of those less skillful and poorly equipped, and therefore in choosing a method of treatment the patient or the attending physician should not only consider the method of treatment, but the human being who is applying that method. Some of the results obtained during the last few years from radiation give us great hope.

PRIMARY CARCINOMA OF THE BREAST

In general, and based upon the experience of the general surgeon and roentgenologist, we are probably justified today in recommending, as I have been doing for about six years, an *ante-operative* course of x-ray treatment covering the breast, the axilla and the supraclavicular region, carrying as much radiation into the tissues as possible within a period of one to two weeks. This treatment is given with the object of making microscopical changes in the tissue, and of so devitalizing the malignant cells that they can not easily reproduce themselves, either locally in the wound or when transplanted by the lymph or blood channels to other locations in the body during the operation. This preliminary radiation should then be followed within a few days by a radical and complete operation which should be done just as thoroughly as if no preliminary radiation had been given. After the operation, and within a period of three to four weeks from the time of the preliminary x-ray treatment, a subsequent period of radiation should be given, during which time the tissues should be thoroughly saturated to the limit of the skin tolerance. If this procedure is followed thoroughly and skillfully the whole process should be complete within two months in an early or average case. If, however, the disease is extensive and metastasis has taken place to the supraclavicular region or mediastinum, more thorough radiation will have to be given, extending over a longer period of time, and the outlook is correspondingly less satisfactory.

Technique. The technique for this ante-operative and post-operative treatment will have to be varied somewhat in the individual case, but in a general way it will be de-

scribed as follows. At least three areas are to be treated, *one*, comprising the mammary region which extends from the median line upward to the level of the axilla and laterally to the mid-axillary line; *second*, the supraclavicular region which extends from a horizontal line drawn through the lower border of the anterior fold of the axilla inward to the median line, and bounded posteriorly by a line drawn through the upper border of the spine of the scapula; a *third*, comprising the scapular and posterior axillary region, which includes the area below the line of the scapula and posterior to the line drawn through the middle of the axilla.

The apparatus used by the individual roentgenologist will to a certain extent vary the remainder of the technique, but in a general way I use radiation through each of these areas coming from a Coolidge tube excited by a transformer, through 6 mm. of glass or aluminum, with a 9 inch parallel spark gap and 5 ma. of current with a focal skin distance of 30 or 40 cm. If 30 cm. distance is used we treat for a period of twenty minutes. If 40 cm. are used thirty-five minutes exposure is given, and each of these areas is covered in this manner twice within a period of two weeks. If it were not for the radiation sickness which troubles us much, I believe that it would be better to use the 40 cm. distance and the longer period of exposure, but it seems that the longer the period of exposure the greater the amount of radiation sickness, and for that reason we frequently use 30 cm. distance and a period of twenty minutes exposure. Each of these applications is distinctly less than an erythema dose, but the two applications given within a period of two weeks amount to more than a single erythema dose, and if this same amount of radiation were given at a single application over each area, it would produce a marked erythema, yet divided in this manner we do not get more than an erythema. This has been one of the greatest lessons learned by us during the past year. For the postoperative treatment these areas are gone over in a similar manner.

PRIMARY CARCINOMA OF THE BREAST TREATED BY RADIATION ALONE

Practically all the cases of primary carcinoma of the breast treated by radiation alone consisted of those which for one reason or another were considered inoperable and in these most satisfactory results have been obtained. The disease has either been made to disappear completely so far as inspection or palpation can determine or, in those cases in which the disease involved a large mass of malignant tissue of the breast area, it was reduced to a fibrous solid mass, movable, which could then be removed locally by surgery. Axillary and even supraclavicular lymph nodes have been made to disappear.

Fig. 1. Case 1. Carcinoma of left breast in male, five years' duration, with projecting mass about 5 cm. in diameter, located above the nipple.

Technique. The technique consists of primary radiation by means of the roentgen rays in a similar manner to that descrbed above for ante-operatve treatment. At the end of two weeks radium needles are inserted throughout the palpable malignant disease. For this purpose I use steel needles containing 10 mgm. of radium in each (length 27.3 mm., diameter, external, 1.73 mm., thickness of wall 0.4 mm.). Under nitrous oxide gas anesthesia these needles are introduced throughout the malignant disease 1½ cm. apart if they are to remain in place only eight hours, and 2 cm. apart if they are to remain in place sixteen hours. The needles must be introduced under aseptic conditions, and into every part of the malignant disease, either at a single application or in more than one application within a period of a week providing the disease is very extensive, and so that no part of the malignant tissue can recover or develop a resistance to the rays

FIG. 2.

FIG. 3.

FIG. 2. Case I. Lateral view to show the projecting epithelioma. The remainder of the breast was indurated. The projecting tumor mass was destroyed by electro-coagulation and radium needles inserted throughout the breast and into the left axilla.

FIG. 3. Case I. Showing end-result six months later. No palpable evidence of malignant disease. Fibrous tissue surrounding the points of insertion of the needle.

while some other part is being treated. A few illustrative cases may be mentioned.

CASE I. Mr. H. H. P., aged sixty-five, was referred for consultation by Dr. Melvin Henry, October 6, 1920. He had had a tumor growing in his left breast for five years, and at this time he had a projecting mass of malignant tissue in the region of the left nipple approximately 5 cm. in diameter and elevated approximately 3 cm., with induration involving approximately two-thirds of his breast. There were no palpable axillary lymph nodes. One of two methods of treatment was recommended, either ante-operative *x*-ray treatment followed by a complete operation and then postoperative *x*-ray treatment; or preliminary treatment with the roentgen rays and then local destruction of the projecting tumor mass by means of electro coagulation and the introduction of radium needles throughout the indurated malignant tissue of the breast and into the anterior axillary fold. After conference with the family physician the patient refused surgical excision and the second form of treatment was carried out with complete disappearance of all evidence of disease. The patient has had no treatment since December 9th, 1920, but returns once a month for observation. The duration is too short to draw any conclusions, but since we have extended our radiation more widely than a surgeon could possibly have removed the tissue, and since we have eliminated by this means all palpable disease, I believe that we have a right to assume that any other smaller and less palpable disease has also been eliminated, but the case is presented primarily as an illustration of my opinion of the latest and best method of treatment rather than as convincing proof of ultimate results.*

CASE II. Mrs. H. S., aged sixty-seven, referred by Dr. N. G. Allebach, November 10, 1920. She had had a tumor of the left breast six years, but never spoke of it until three days before she was sent to my office. She had suffered from pains for about a year. The patient had a tumor involving the entire left breast with an area of ulceration approximately 8 cm. in diameter with a mass of metastatic glands in the axilla the size of a hen's egg, and with large palpable lymph nodes in the supraclavicular region, and by *x*-ray examination distinct mediastinal disease. In this case we had to treat not only the affected side but the opposite side of the chest in order to reach the mediastinal tissue and to prevent any extension to the opposite breast. It required twenty-six days to get this preliminary treatment by the roentgen rays. Then on December 7th we introduced 200 mgm. of radium in the tumor for fifteen hours. On December 8th we introduced 100 mgm. into the outer portion of the tumor mass for eight hours, and 100 mgm. into the central and remainder of the tumor for a period of four hours. From December 2nd to February 1st we covered the entire area again by *x*-rays. On January 17th we

* He is still well (November 7, 1921).

FIG. 4.

FIG. 5.

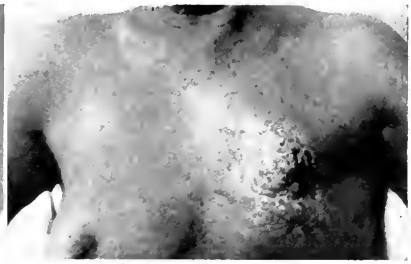


FIG. 6.

FIG. 4. Case 2. Advanced inoperable carcinoma of the left breast, duration six years. Extensive lymphatic involvement in the axilla and supraclavicular regions.

FIG. 5. Case 2. Lateral view showing projecting tumor mass and a crayon outline showing the extent of axillary glandular involvement.

FIG. 6. Case 2. Showing disappearance of all evidence of malignant disease six months afterwards as a result of radium and x-ray treatment. Fibrous mass occupying region of former tumor is movable and will probably be removed later.

introduced 150 mgm. of radium throughout the tumor of the breast for eight hours. On January 17, 200 mgm. for fifteen hours through other parts of the tumor of the breast and into the axilla. Between February 15th and March 2nd we gave the third course of x-ray treatment. On March 23rd we introduced 70 mgm. of radium into parts of the tumor mass which still gave evidence of malignant disease, and 80 mgm. of radium into the lymph nodes in the axilla. On April 20, 1921, we introduced 100 mgm. of radium for six and a half hours into the only evidence of malignant disease which was in the axilla, a lymph node that did not seem to be completely reduced to fibrous tissue, and on April 27th a general area covering the entire left supraclavicular and mammary region was treated by the roentgen rays. She now seems to be free from any evidence of malignant disease, but the area in the breast that was formerly occupied by tumor tissue is now apparently a mass of fibrous tissue which is movable, and which we will probably have removed surgically at a later date. This illustrates the method that I believe should be employed to render an inoperable case operable.*

CASE III. Mrs. L. M. E. T., aged seventy-one, was referred to me by Dr. Wm. Erdman, February 1, 1921. Two years previously she discovered a tumor in her right breast. This had increased and had become more painful. At the time that she came for examination she had a tumor mass in the upper inner quadrant of the right breast 8 cm. in diameter and approximately 5 cm. in thickness. It was undoubtedly malignant. There was no axillary involvement, but in this region the likelihood of metastasis would be towards the mediastinum. The patient had not told anyone of the tumor and feared an operation. Considering the likelihood of extension and the duration of the disease we felt that her chances for recovery were probably greater from radiation than from surgical excision and therefore we applied the roentgen rays very thoroughly over the mammary region and from every direction through the chest toward the mediastinum. On March 10th we introduced 200 mgm. of radium into this tumor tissue for a period of six and a half hours. On May 4th the disease had practically disappeared, but there were a few doubtful areas that we felt might still be malignant. Therefore we introduced 100 mgm. of radium with needles into these suspected areas for a period of six and a half hours. At the present time, so far as we can tell, she is free from disease. This is not reported as a cure, but illustrates the type of case in which we are, I believe, justified in using radium treatment and in which I believe we may hope for success. Frankly I believe that she will recover and remain well, and in this type of case I believe that her chances are better with radiation than they would be with operation.*

RECURRENT AND METASTATIC DISEASE

Recurrent and palpable metastatic disease

*The fibrous and necrotic area was removed by the thermocautery by Dr. Laplace, October, 1921. Patient is in good condition and there is no evidence of malignant disease (November 10, 1921).

*She has no palpable malignant disease (November 9, 1921).

FIG. 7. Case 3. Carcinoma in upper inner quadrant with some evidence of mediastinal disease in a woman of seventy-one years of age, which has entirely disappeared under *x*-ray and radium treatment. Duration of the disease, two years. Finished photograph not yet made.

must be treated according to the principles which are involved in the preceding description. In general, recurrent and metastatic disease is the least satisfactory to be treated by any method, because it is utterly impossible to decide definitely the extent of the disease, but in many instances most remarkable results can be obtained. In a general way, the roentgen rays should be applied according to the methods described in the previous two groups, making every effort to extend the radiation beyond the area of the disease. It should be our aim to give as much radiation as possible in the shortest period of time possible until the disease is entirely gone. After the general treatment has been given, the localized and definitely palpable and visible disease should be treated either more intensely with the roentgen rays or preferably when possible, by the introduction of radium needles directly into the diseased tissue according to the principles above described, or when it is impractical to introduce these radium needles, surface applications of radium should be used with filtration equivalent to at least a millimeter of brass and with sufficient distance and time to get an effective distribution of the radiation over the entire lesion involved. When radium is not at hand, more intensive *x*-ray treatment should be used, sufficient to destroy the local disease. To illustrate this group:

CASE IV. Mrs. J. D. C., aged forty-three, was referred to me by Dr. Francis Sprague, on March 13, 1920. Her right breast had been removed, August 10, 1910. Later a small ulcer was removed from the scar and the rib was scraped by the same surgeon. The ulcer in the scar had not healed. On March 13, 1920, she had a nodule in the right axilla, 2 cm. in diameter and 1 cm. in thickness, firmly attached to the rib with an ulcerated area in the lower part of the scar approximately 5 cm. in diameter with indurated edges and undoubtedly malignant. The opposite breast was distinctly malignant with a tumor mass the size of half a hen's egg and lymph nodes from 1 to 2 cm. in diameter extending along the entire anterior fold of the axilla, with nodules in the left axilla and the left supraclavicular region, with distinct evidence of malignant disease within the mediastinum and with pains and numbness extending down the thigh.

The patient was first treated very thoroughly over the entire chest anteriorly and posteriorly and the treatment was carried along the spine entirely down to and including the pelvis. This preliminary *x*-ray treatment required approximately a month, and as a matter of fact was practically continuous at intervals of a few days during a period of two months, during which time the entire body was covered twice. Radium was applied locally over the ulcerated area by surface application and over the lymph node in the right axilla. In the left breast and axillary region radium needles were inserted throughout the tumor tissue. This radium treatment was all given within a period of two months, when all palpable evidence of disease had disappeared. Her chest has been radiated by the roentgen rays three times since, the last treatment being given in No-

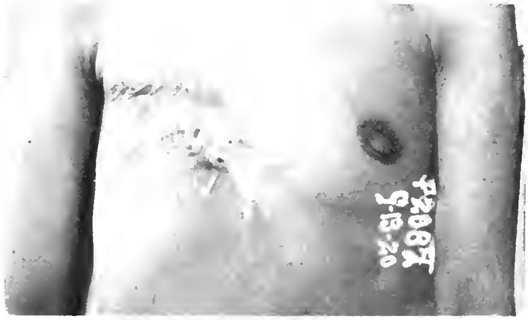
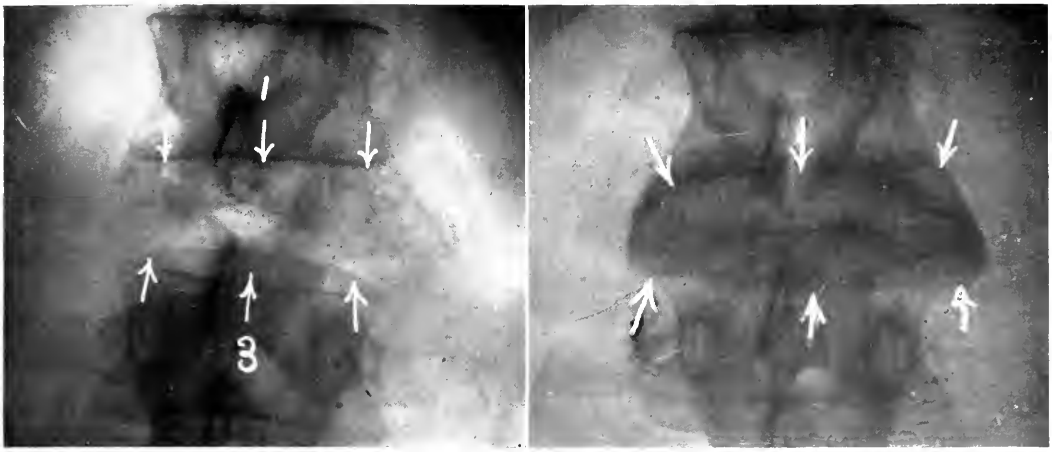


FIG. 8. Case 4. Showing disappearance of all evidence of malignant disease and healing of the ulcer described in the text. Tumor mass in the breast and lymph nodes in both axilla and supraclavicular region disappeared. Primary photograph not made.



A. B.

FIG. 9A. Case 6. Showing complete destruction of the lumbar vertebra due to metastatic carcinoma secondary to carcinoma of the breast.

FIG. 9B Case 6. Showing complete recalcification and healing of the vertebra one year later. Patient doing general housework three years later, and free from disease.

vember, 1920. All palpable, visible and roentgenographic evidence of disease has disappeared, and so far as I can tell she is free from disease today.

CASE V. Mrs. G. H. G., aged fifty-two, was referred to me on March 30, 1912, by Dr. John B. Deaver, on account of recurrent carcinoma following an operation for removal of the right breast four months previously. When referred to me she had had an area of recurrence with indurated tissue at the inner side of the scar over an area 3 x 1½ inches, and each stitch hole showed thickened tissue. The arm was swollen. The whole area was painful and the lungs showed some fine miliary infiltration. Under thorough radiation this disease disappeared completely within a period of a year and has never recurred. She reported from time to time for inspection, but it was unnecessary to give more treatment until September 26, 1919, or seven years later, when she returned on account of pains in the region of the left shoulder and upper dorsal regions. At this time examination of the chest showed nothing within the lung area that suggested carcinoma. There was no evidence of disease of any kind in the left humerus or the left shoulder joint, but there was disease involving the sixth, seventh and eighth dorsal vertebrae, which I believed to be metastastic carcinoma. She had associated with this some evidence of an osteoarthritis of the spine, and it was impossible to say definitely whether this was metastatic carcinoma or not, but I believed it to be so. Under *x*-ray treatment all symptoms and evidence of disease disappeared and she received no treatment for at least six months. This illustrates in an indisputable manner, the disappearance of recurrent disease under the influence of the *x*-rays. It also illustrates the fact that metastatic disease may still develop in some other part of the body which may require treatment, but even when such disease develops as long as seven years after, it need not be considered hopeless.

CASE VI. Mrs. C. P., aged forty-three, was referred to me, March 27, 1918, by Dr. C.C. McCormick. Dr. John B. Deaver amputated the right breast for carcinoma, March, 1917. After the operation and during eight or nine months the patient had pains in the spinal region. She had been bedfast for fifteen weeks before being admitted to the hospital, and came to the hospital on a stretcher. X-ray examination showed destructive disease, undoubtedly metastatic carcinoma, involving the eighth dorsal vertebra with almost complete destruction of the second lumbar vertebra. The patient was sent to the hospital against my advice and without my permission because from the history I judged that she would be a hopeless case, for it is my opinion that when carcinoma involves the bones it must be looked upon as a part of a general carcinomatosis, and while one may get local healing in the lesion act-

ually under treatment, the great likelihood is that the disease will have extended beyond the actual areas which are treated. This subject has been discussed in detail in a previous paper.[5] Under the circumstances, however, she was treated over the entire spine anteriorly and posteriorly. In fact, the entire body was covered by treatment, not including the extremities. After a month the patient was placed in a celluloid jacket and allowed to get out of bed. In six months she was doing her own housework, including her washing and ironing and has continued to do this ever since. She has been given eight courses of treatment and was treated last on September 27, 1920. An *x*-ray examination of the spine and other bones of the body on May 19, 1921 showed no evidence of disease anywhere in the bones. She had gallbladder symptoms which brought her back to the office, and *x*-ray examination showed some enlargement of the liver. Whether this is due to metastatic carcinoma or not I cannot say, but the fact remains that she has lived at least three years longer than she could possibly have lived otherwise, and is still in fair health. It is entirely possible for a patient who has had carcinoma to develop some inflammatory condition of the liver just as any other patient might do, though after such history one naturally thinks of the possibility of metastatic carcinoma of the liver.

CONCLUSIONS

1. Roentgenologists should make a study of carcinoma of the breast and its treatment with the same thoroughness that the surgeon has employed.

2. The best procedure for the treatment of primary carcinoma of the breast will probably consist of ante-operative *x*-ray treatment followed promptly by an operation, and again promptly by postoperative *x*-ray treatment.

3. For inoperable primary carcinoma of the breast a reasonable hope of success can be entertained as a result of radiation treatment by roentgen rays and by radium, providing it is skillfully and thoroughly used; and the earlier it is applied the greater will be the success.

4. Recurrent and metastatic carcinoma from carcinoma of the breast can frequently be made to disappear completely by thorough and skillful application of either radium or *x*-ray, but probably better by a combination of both, and success can be hoped for providing the disease is localized to the area treated.

5. All patients should be kept under observation and should be requested to report for examination at increasing intervals for an indefinite time.

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RADIUM IN THE TREATMENT OF CARCINOMA OF THE BREAST AS AN ADJUNCT TO SURGERY*

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DURING the four years preceding January 1, 1921, I treated a total of 817 patients with radium. The 109 cases of cancer of the breast reported in this paper are taken from this list. The cases in this report have been followed to April 1, 1921. All but twelve of these were treated since 1918.

They naturally divide themselves into the following classes:

1. Postoperative radium cases; i.e., cases

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in which radium was used directly after a radical operation. There were 43 of these cases.

2. Postoperative recurrence cases; i.e., those cases which had had a radical operation some time previously, and a recurrence before radium was used. There were 44 of these cases.

3. Non-operative cases. Six too hopeless for any surgery, and 4 which refused any operative intervention—10 in all.

4. Cautery only cases. The disease being too far advanced for any other surgery. There were four in number.

5. Pre-operative and postoperative radium cases; 8 in number.

An analysis of these 109 cases shows: that 11 were unimproved; 29 improved for three months; 12 improved for six months; 6 improved for nine months; 14 improved for one year or longer; 5 are free from disease for three months; 7 for six months; 4 for nine months; 9 for one year; 4 for one year and a half; 2 for two years; 2 for two and a half years; 1 abandoned treatment; 4 are totally untraced; 6 are partially traced; 14 had metastases. Other than axillary; 3 died from intercurrent disease; 2 had radium used before operation; 7 died within three months; 17 died in six months; 7 died in nine months; 4 died in one year; 5 in one year and a half; 3 in two years; 53 patients are still living.

One of the cases in the postoperative class was a male— a Christian Scientist, who had nursed an ulcerating pus-discharging sinus in his breast for three years before he submitted to surgery and radium. He recovered his health for well over a year, abandoned his treatments, returned to his Christian Science love, had a recurrence and died in a year and a half after his operative procedure.

One of the cases in the postoperative class with cancer of the vulva and who had been well from same for two years, had an incomplete operation for cancer of the breast. This cancer had resulted from a kick of a cow ten years previously. She had a recurrence in the breast wound before she left the attending surgeon's hospital. She improved temporarily after radium therapy, but died from the later cancer in six month's time.

No case was too far advanced to be refused treatment. Twenty-six cases, including the 6 previously mentioned that could have no operation, were apparently hopeless, the other 20 being taken out of the recurrent cancer cases. The analysis shows, however, that only 11 of the entire list were unimproved.

One patient had a cancer paste used unsuccessfully on an axillary recurrence before her radium therapy. She now seems well one year after her treatment.

Of the cases submitted to cautery, 2 were cauterized before radium and 2 were cauterized after previous radium treatment.

Seven of the 8 cases listed under preoperative and postoperative radium therapy are classified as acute fulminating carcinoma of the breast; i.e., a condition in which there is a widespread involvement of the breast, with a rapidly growing, recent or acute virulent cancerous process, with axillary metastases— a fixity of these glands and often a supra- or subclavicular involvement— a condition which is recognized by good surgeons as being hopeless for surgery alone. Five patients with this variety of cancer are living today; at least 2 seem to be well over a year after their operations; one such case died with a metastasis of the liver, which she must have had before her surgery and radium. Up to the time of her death, several months after her treatment, she had no recurrence in the breast area. The other patient who died did develop a recurrence in the breast area, which caused her death in five months. The eighth case which had preoperative and postoperative radium, was a case of long standing carcinoma, with axillary and supraclavicular metastases. She improved so much after radium alone that she was submitted to cautery of the breast area, after which she was again treated with radium, and appears well eight months after her treatment, her supraclavicular and axillary involvement disappearing from radium treatments alone.

One of the fulminating cases had numerous superficial skin recurrences, which required frequent extra treatments. She is a fat, heavy-eating Jewess, and her indiscretion with her diet, accompanied by a radium skin reaction, has left her with a widely diffuse eczematous dermatitis over the whole

breast area. She is slowly recovering from this trouble. The fact that she has this eczematous process affecting both ears, relieves the radium from some of the blame for the superimposed condition.

The results we seem to be getting in this hopeless fulminating variety, are the real excuse for this paper. It really converts one to the idea that many, if not all, of the supposedly good surgical risks, should be submitted to both pre- and postoperative irradiations with radium.

Of the 43 cases submitted to operation, the first 5 were in their thirties; 11 were in their forties; 19 were in their fifties and 8 in their sixties.

Of those which had pre-and postoperative treatment, 3 were in their forties; 3 in their fifties, and 2 in their sixties.

Of those which had recurrences, cautery only, or no surgery, 6 were in their thirties; 17 in their forties; 19 in their fifties; 3 in their sixties, and 3 in their seventies—the youngest being thirty years of age. Contrary to expectations, and unlike the cases of cancer of the cervix and uterus, the results obtained in the youthful patients, who had radical operations, have been almost as good as with patients in the normal cancer age. One patient thirty-one years of age, operated last September, and with no recurrence to date, has just returned with a cancer of the opposite breast. She has had this breast removed, and is receiving her postoperative radium therapy now. Twenty-five patients of the 43 treated after radical operations, are living. Many are apparently free from disease.

Patients in the thirties, who had recurrences before treatment, did not do so well, but the results in all the recurrent cases have not been as good as when radium was used directly after surgery. Fifteen patients in the recurrence class are living.

Only the patients who had distant deep metastases, were submitted to *x*-ray therapy in conjunction with their radium treatment.

DOSAGE

After trying various doses of radium, variously screened, on the postoperative cases, using as a minimum 50-75 mgm. in a pack and a maximum dosage of 250 mgm., it was finally decided that the best results were obtained by the use of a 100 mgm. surface pack, made up of 4, 25 mgm. tubes, each screened with a 1m. brass cylinder. These tubes are placed side by side between double thickness of black vulcanizing rubber which is cured only on one side; cutting along on each of the four sides with a pair of scissors, makes a self-sealing pack. The gauze dressing on the patient is arranged to make a thickness of 1 cm., and squares the size of the pack are marked on top of the binder. The whole breast axillary and clavicular areas each receives a four hour application with this pack.

Depending on the size of the patient, 22 to 30 areas are treated, granting a day of rest between each twenty-four hour application. At the time of the operation, if there has been an incomplete axillary gland removal, or if the axillary gland involvement has been extensive, a black rubber drainage tube, the diameter of a lead pencil, with a closed end and fenestrated sides, is sewed in place for the future insertion of radium capsules. Fifty to 100 mgm. of radium unscreened, or screened with 1 mm. brass, is fastened on wires and inserted full depth into this tube, and left in situ eight to ten hours, depending on the condition. If the area which the tube penetrates is sufficient in length to require moving the radium, it is a simple matter to pull the wires and bend them over the end of the tube. As the radium sets up quite a reaction when used in this manner, it is necessary to remove the rubber radium tube gradually to allow for drainage. If the tube is removed too suddenly, retained secretion will simulate an abscess, materially delaying healing.

It is quite necessary that the patient be instructed to freely and forcedly use the arm, after such a procedure, to prevent scar tissue formation in the axilla, and resultant limited motion and painful swelling of the arm. We have these patients stand side-wise to a wall, with the arm extended, and have them endeavor to reach a higher mark on the wall with the fingers, each day.

The treatment used in the pre- and postoperative cases, consists in using the same surface pack in the manner described above; there is this difference—1½ to 2 cm. of gauze is used between the radium and the patient, and the areas are covered twice,

just before the operation, and immediately afterwards, and the pack is moved every three hours instead of four hours. There is more or less skin reaction after such a double exposure, but the healing of the wound is not interfered with to any extent, and the radium reaction of the skin generally responds to the use of ambrine or parresine wax dressings, as is used for heat burns.

In treating the recurrences, a 50 to 75 mgm., pack with the brass screen, rubber and little or no gauze is applied to each recurrence area, three, four or five hours; or radium needles or tubes are imbedded for three to eight hours as the case may require. A Wassermann is run on all these patients, and an *x*-ray picture of the thorax in advanced cases is made to eliminate bone and lung metastases.

X-ray pictures have disclosed metastases in the vertebrae or bony pelvis, in several patients suffering with pelvic and lumbar pain. When a case is so far advanced as to have such metastases, little or no benefit has been obtained from deep *x*-ray and radium therapy; they have all died rather promptly.

CONCLUSIONS

1. Radium therapy, after a radical operation for cancer of the breast, greatly lessens the chances of recurrence.

2. In local recurrences of breast cancer, its use often meets with success.

3. In the non-operative cases—those which were inoperable, and those which would not submit to surgery—the results obtained by radium treatment alone encourage one to its continued use.

4. The pre-operative and postoperative use of radium in cancer of the breast, is highly recommended, particularly in the virulent cases.

DISCUSSION OF PAPERS OF DRS. KIRKENDALL AND PFAHLER

Dr. Charles Goosman, Cincinnati, Ohio. I wish to know whether in using radium Dr. Kirkendall gets a uniform tanning of the chest or patches. In other words, whether the results are as good as with *x*-rays. I have always preferred *x*-rays to radium, except perhaps in the axilla, and I would like to have Dr. Goosman explain that part of it.

Dr. Isaac Levin, New York City. In regard to the combination treatment with radium and surgery in carcinoma of the breast, I believe that the new method of inserting radium emanation needles into the tumor mass, two or three or perhaps four weeks before the operation is done, offers a method which may increase the number of operable cases of carcinoma of the breast. In several cases that have appeared to be inoperable we have used that combined method of inserting radium needles into the mass of the tumor and in the axillary glands that are far enough away from the blood-vessels, with the result that in several cases the results seem very good; and I believe the ultimate results will probably be superior to surgery alone, because microscopic analysis shows that the carcinoma in the primary mass has practically disappeared.

I have here a specimen which shows the gross change in the mass around the radium emanation needle. You will see a great deal of bloody extravasation, and if you look closely near the center, the necrotizing area of the carcinoma. If you place a sufficient number of radium emanation needles of 1 mgm. or ½ mgm. in the tumor, it will show that the whole tumor mass is filled with such areas.

Dr. D. T. Quigley, Omaha, Neb. I think we should not pass over these papers without some reference to Paget's disease. I wish to report that during the last seven years I have been engaged in radium treatment; in the first three years I encountered 6 cases of Paget's disease. Another point we have been overlooking is the pathology involved in these cases. We do not study enough pathology and if we understood it a little better we would get better results. Paget's disease is a particularly malignant thing, probably the most malignant disease of the breast, and we should always remember that these patients are subject to this disease. During my first three years I encountered six women who refused operation. Today four of these women are still living, 66 per cent cures. They have had no treatment but radium on the Paget nipple. They were all typical cases of Paget's disease, with the erosion and the punched-out condition, but no involvement of the glands. Pathologists have been discussing whether this condition begins on the outside and works in or on the

inside and works out. Personally, I think it begins on the outside and works in, and my results in these cases have borne out this belief. We used 50 mgm. directly on the ulcer, screened only by ½ mm. of silver and ½ mm. of rubber. This is a particularly small dose.

The technique of these breast cases in general is interesting. I believe they should be submitted to operation. I still operate on Paget's disease when the women will submit, and I believe they should be operated but that they should be submitted to operation first. In the breast we use x-rays and in the axilla radium. I believe Dr. Kirkendall is a little small in his doses. We use about four times as large a dose as his, following operation, and get no swelling in the arm. We do not remove as much muscle, but we believe in pre-raying.

As to the point brought up by Dr. Levin, that they should be operated three weeks after raying,—I don't care if they are operated three hours after raying. The thing we are after in the raying is the cells that are disengaged, floating perhaps in the lymph or blood stream, disengaged, floating cancer cells, that would implant themselves very easily without raying. They are the things that give us the recurrences, and if we kill them we have delivered the proper dose to the cells. Immediately we are through with each raying, it does not make any difference whether the operation takes place in three hours or three weeks, except that at the end of three weeks we have some scar tissue, which we do not have in the early days.

Dr. Douglas Quick, New York City. It seems to me that in this group of cases we have very definite fields for x-rays on the one hand and radium on the other. X-rays lend themselves to distribution over a wide surface, while radium is confined, at present, very largely to local application. I think x-rays are our routine method and, barring that small group that should not be treated by any means, should be used in every case. In localized masses that are not to be operated upon we can use radium to the best advantage. The type of the nodule determines whether surface application, or radium buried in some form should be used. In our work we use radium buried in all of the localized nodules possible. I see no reason why the radium salts in tubes should not have the same advantage. Then we can determine exactly what we wish to accomplish by the treatment. I do not think we should first use x-rays and then stick some needles in and eventually operate. We have to change our plan occasionally, but we can usually map out a plan of procedure at the beginning.

I thoroughly agree with Dr. Pfahler as to pre-operative radiation, and should like to know whether he operates soon or late. In our work we have not found marked histological changes until upward of a month. I think it is important to get these changes before any surgical intervention. Much depends on what you wish to accomplish by the raying. I believe that our views of operable cases will be steadily but surely changed when we consider the statistics to date. I think the most reliable surgical statistics, when the axillary nodes are involved, give the patient one chance in twenty-five of being alive eight years later. There are still a certain number of patients who absolutely refuse operation, and others in whom operation is contraindicated. In these I think the radium emanation or the tubes buried in the tumor are of the greatest value. In view of our experience, I am not so sure that we should urge unreasonable operative intervention. There are other cases, again, where the very widespread distribution of the disease, I think, prohibits the use of very much emanation, especially where there is much sloughing of tissue, and the danger of introducing infection is to be considered. So I think we should use x-rays in every case, just as though no radium were to be used. When we use radium it is an agent added to the x-ray.

Dr. Henry K. Pancoast, Philadelphia, Pa. Dr. Quigley made a statement a little while ago that I would like to hear discussed. He stated that it made no difference whether a case was operated within a few hours or several weeks after ante-operative radiation. We have to consider two points: first, the complete destruction of the cancer cells by the pre-radiation and the protection that gives the patient and, second, whether or not it is true that pre-operative radiation will set up the body defense against metastases by closing the lymphatics. If the latter point has any value we must certainly wait a little while before operation is performed, because the lymphatics will not be closed off within a few hours. If there is no value in closing the lymphatic channels, it will make no difference whether we operate at once or wait for a time.

Dr. John Lincoln Bower, Philadelphia, Pa. In reference to the remarks made by Dr. Pancoast, I have had an opportunity to study some microscopic specimens where there were glands in the axilla, and we found that where the cases were operated within twenty-four hours practically no fibrous change at all was present. If these cases were permitted to go on and wait for a month there would be a fibrous change. If the needles were allowed to remain

for forty-eight hours there was distinctly changed tissue. This was noticed in the carcinoma, where the capsule had been increased in thickness about three times, and the gland had been reduced in size. The needles contained each 2½ mgm., applied for twenty-four to forty-eight hours.

Dr. Henry Schmitz, Chicago, Ill. I think it depends upon how much radiation is absorbed, whether one uses *x*-rays or radium. If the absorbed dose is sufficient to kill the cell, all right; if not, it might stunt its growth. The question is whether we wish to have the stunting of the cell, or whether we wish to wait for the development of the toxin which protects the patient against the further invasion of the carcinoma. I feel that the radiation must be given to the extent that it kills all the cancer tissue. If all the cancer tissue is killed I do not think there is any necessity for operation. If the cancer tissue has disappeared entirely, I consider the patient well and believe that I have obtained as good a result, or probably better, than would be possible with surgery and I would not do an unnecessary operation. If you feel you must operate, it seems to me this should be done at the time when the patient has obtained the full benefit of the radiation. This will surely not be obtained within one day or two or three, but in my opinion, from four to six weeks will elapse before the patient has obtained the full benefit against the further spread of cancer.

After all has been said, we must realize that our results in radiation therapy will improve and be much better than they have been if the radiation is applied in the localized, or practically localized, cases. When metatases have formed it is impossible for us to state *a priori* whether a patient is suffering from a general cancer disease. If from a general cancer disease, the patient cannot be benefited but will be rendered worse by operation; I believe those who have treated the most cases will agree with me on this point.

Dr. Ben R. Kirkendall, Columbus, O. (closing discussion on his paper). Answering the question about the tanning, when radium plaques are used the tanning reaction is very generally distributed after such a treatment. The patients get blisters and a thickening of the skin, two or three times as much as should be, but this disappears in two or three months. In burying the radium in the cancer and giving 100 mgm. for twenty-four hours, I have tried to give twelve hours unscreened. Some of these cases get a great deal of reaction and do not heal as well as others; in some there was a fibrosis of the tissue, eventually thrown into the axilla and limited to the arm, with resulting shutting off of the swelling in the arm and some pain; some get along well with the shorter dosage and some do not.

As to the advisability of operating immediately after the radium therapy,—we adopted that plan thinking it would prove curable, or inhibit the cancer cells, and that we would catch the ones that were not killed by the little dose of radium.

I agree with Dr. Quick about burying needles for ten or twelve hours, depending upon the condition. That can be done with very good success, and we can move them about to different parts of the growth until we cover the whole thing. If we think the patient has a generalized carcinomatosis, or metastases other than in the subclavicular or axillary spaces, those cases are not operated upon.

DOSAGE IN RADIUM THERAPY*

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IN THE past the problem of dosage in radium therapy has been treated primarily, and almost exclusively, on the basis of the radiation *emitted* by the radioactive source. Obviously, however, it is only the radiation *absorbed* by the irradiated tissue which is responsible for the observed effects. Radiant energy, like any other form of energy, may be expressed in ergs, calories, joules, etc., there being many different units of energy. To specify the amount of radiation absorbed by tissue, we may use, therefore, any one of these units, or define an entirely new one. In the present paper is suggested a method of dosage based on the radiant energy absorbed by tissue, measured in calories. Calculations were made which show the feasibility of the method and its advantages.

The medical man is familiar with the Law of Conservation of Energy on account of its application to the thermodynamics of the human system. He knows that exhaustive calorimetric experiments have shown that the amount of energy appearing as heat and mechanical work is exactly the same as the amount produced in the chemical changes which food undergoes in the system. The physicist believes in this law because up to the present not one single instance has been found in which it does not hold. Judging from past experience, therefore, he is justified in assuming that the law will continue to be true. His expectation is based on the same kind of reasoning which makes every one of us feel certain that the sun will rise tomorrow. With the discovery of radium and the study of its radiations came the question of the origin of the relatively enormous quantities of energy produced during a radioactive change. It soon became apparent that the energy liberated came from the atom itself, in which it was stored before the change. Experiments show that 1 gm. of radium, in equilibrium with its products, produces 134 calories of energy per hour, that is, enough heat to melt more than 1½ gm. of ice per hour. The relative amounts of energy associated with the different types of radiation are as follows: alpha rays, 92 per cent; beta rays, 3.2 per cent; gamma rays, 4.8 per cent.[1] Hence most of the energy is carried by the alpha particles. When radium or emanation in tubes is used as a source of radiation, the alpha particles are unable to leave the container, and therefore, at best, only 8 per cent of the energy is available for therapeutic purposes. If a filter is used to remove the beta and soft gamma radiations, then probably about 3 per cent of the total amount of energy is at our disposal in the form of penetrating gamma radiation.

The law of conservation of energy tells us that whatever effect is produced in living tissue after irradiation, must be due primarily to the energy absorbed by the tissue from the radiation traversing it during the treatment. Therefore let us consider briefly the process of absorption. Very little is definitely known about the action of radiation on the living cell. Our present knowledge of physics, however, enables us to make a beginning. It has been known for a long time that radioactivity is an atomic phenomenon. The different types of radiation are produced by changes which take place in the atom itself. Conversely, when the radiations strike a substance, their first effect is on the atoms of the material. Some are broken up into particles carrying positive and negative charges of electricity, and the substance is then said to be ionized. The energy necessary to produce the ions is supplied by the radiation, which consequently suffers a loss. The substance, therefore, is said to absorb some of the radiant energy which traverses it. The presence of ions in a substance makes possible chemical reactions which ordinarily do not take place spontaneously in the substance. A part may be broken up into its constituent elements, or a regrouping of the atoms may take place, resulting in the formation of compounds which were not present before. There is abundant evidence of the chemical action of the radiations.[2,3] For

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instance, water is decomposed into hydrogen and oxygen, and at the same time hydrogen peroxide is also formed. The process is reversible, so that hydrogen and oxygen are caused to combine to form water and hydrogen peroxide. Hydrogen may be changed into a new form, H_3,[4] and ozone is formed from oxygen. While these reactions are brought about principally by alpha rays, the beta and gamma radiations also have an effect on water. Kernbaum[5] has made the interesting observation that the penetrating rays produce hydrogen peroxide and hydrogen, but no oxygen, by their action on water. Other substances besides water are affected by radium radiations.[2] In fact, it is reasonable to suppose that all substances are affected to a smaller or greater extent. Bearing these facts in mind, we can safely assume, at least as a working hypothesis, that the effects of radiation on living tissue take place in three stages:

1. The tissue is ionized at the time of its irradiation.
2. Unusual chemical reactions take place on account of the presence of ions.
3. The equilibrium of the cells is therefore disturbed and the observed changes are brought about.

This conception of the action of radiation on living tissue, while it does not "explain" the process, is helpful in our understanding of the problem of dosage.

From the preceding discussion it is evident that the physiological effect of radiation must depend, if not entirely, to a considerable extent, on the ionization produced in the tissue. This in turn depends on the amount of energy absorbed by the tissue. It follows, therefore, that the amount of energy absorbed by the tissue offers a good basis for the specification of doses of radiation. But we cannot assume that the energy concentration with respect to space and time has no effect on the final result. For, obviously, the same amount of energy in general will produce quite different results if it is absorbed by one cubic centimeter of tissue or one hundred cubic centimeters of tissue, also, if the time during which it is absorbed is very different. For instance, if the source of radiation is weak enough, we may apply it on the skin for one year without producing a visible effect. Yet the total amount of energy absorbed, and the total ionization produced may be larger than in the case of an actual treatment. For the comparison of doses of radiation we may take, therefore, the total energy absorbed per cubic centimeter of tissue and the amount absorbed per cubic centimeter per hour, the latter indicating the intensity of the treatment.

At this point it is perhaps well to emphasize the distinction between the amount of radiant energy emitted by the radium during the treatment and the amount which is absorbed by the tissue and is therefore effective in bringing about the changes. The latter is what can be properly called the *dose*. Of the total amount of energy set free, in general only a very small amount is utilized even under the most favorable conditions. But what is more, the fraction which is utilized depends very largely on the method and conditions of application. If a physician prescribes salts to a patient and the latter buys one pound of salts but takes only one ounce, we cannot say that the dose was one pound. Similarly, in radium therapy we should never say that the dose was so many milligram-hours without further qualifications. This represents only the energy consumption during the treatment and not the useful energy.

There are several reasons for the desirability of an adequate method of specifying doses. In the first place we want to duplicate results when the clinical conditions are, if not exactly, at least nearly, the same. Secondly, if we have determined empirically the dose sufficient to affect a certain type of tumor under a definite set of conditions, we wish to be able to calculate the effective dose for the same type of tumor under a different set of conditions when we are unable to use the same conditions of application as for the empirical determination. Thirdly, we want to compare the effective doses for different types of tumor, as well as the doses which normal tissues can tolerate. Finally, and in general, we must have an accurate method of comparing doses for the study of the effects of radiation on living tissue.

No matter what we select for our unit of dose or the unit of radiation, in the ultimate analysis we must express it in terms which the clinician can apply directly in the treatment of patients. For instance, it is very well to say that a certain lesion requires a dose of one "rad" or 170 "electrostatic units" of

radiation, but the clinician wants to know how he is to obtain that dose with his tube of 50 mgm. in a silver capsule 0.5 mm. thick. If he is told to put a tube on the lesion at a certain distance and for a certain time and gets a good result he will call that an effective dose, no matter what other name may be given to it. Whatever unit of dosage we may ultimately adopt, in our records, we must have in the first place a complete statement of the clinical conditions, that is; history of the lesion, diagnosis, location, size, extent of infiltration, etc., etc.* Then the physical conditions of the treatment must be specified carefully. They are:

1. The strength of the radioactive source.
2. Its distribution.
3. The total filtration used.
4. The duration of the irradiation.
5. The relative positions and distances of the source of radiation, pathological tissue, and normal tissue.

The last is of importance, not only on account of the rapid diminution of radiation with distance from the source, but also because the success of a treatment depends to an undetermined extent on the reaction of the whole system, besides the local effect of the radiation. If too much destruction is caused in normal tissues the healing process is retarded, or it may not take place.

If the above data are available it is possible to express the dose in any unit we please. To indicate the method of calculating the amount of energy absorbed by tissue we shall work out an example. Given: (1) a tube of emanation of 100 millicuries. (2) 14 mm. long, 0.5 mm. in diameter. (3) Filtration 2 mm. of brass and 3 mm. of rubber. (4) Time of exposure, 8.6 hours. (5) Distance from skin, 2 cm., using a cork of this thickness with a 2 cm. hole. (In this example we shall consider only the effect on the skin.) Observed result: a definite erythema in about three weeks. What is the amount of energy absorbed by a piece of skin 1 sq. cm. in area and 1 mm. thick directly below the tube?

The total energy emitted by 100 millicuries of emanation is 10.9 gm. calories per hour. Of this energy only 1.08 calories per hour is emitted in the form of beta and gamma radiation. The filter removes all the beta and soft gamma radiations, therefore the energy of the filtered radiation emitted in all directions is roughly 0.4 calories per hour. The area of a sphere 2 cm. in radius is 50 sq. cm., hence the radiation which reaches the square centimeter of tissue under consideration is only 1 / 50 of the total emitted through the filter, or 0.008 calories per hour. (Owing to the fact that the source of radiation is not a point, the amount of energy reaching 1 sq. cm. of skin is still less, but for our present purpose we need not take this into account). The coefficient of absorption and scattering by tissue[6] for the radiation of this example is about 0.007 $mm.^{-1}$ Therefore the amount of energy absorbed (and scattered) by a piece of skin 1 sq. cm. in area and 1 mm. thick is $0.0008 \times 0.007 = 0.000056$ calories per hour, or .56 microcalories per hour. The amount actually absorbed, that is, exclusive of the amount scattered, is considerably less than this value, but since no accurate value of the true absorption coefficient is available, we need not attempt a closer approximation. Furthermore, for purposes of comparing doses, when the same filtration is used, this is fully sufficient. The total amount of energy absorbed during the treatment is 436 microcalories, for a point source and 415 microcalories for the tube. How this small amount of energy can produce the profound changes in the tissue which we observe, we leave to the biologist to explain. It may be well, however, to compare the amount of radiant energy which is sufficient to cause a definite effect in the skin with the production of heat in the human body. Calorimetric experiments have shown that a man produces about 100 large calories of heat per hour, when sitting and at rest. If we assume the average weight of a man to be 68 kgm., the heat production per gram, or per cubic centimeter is $\frac{100,000}{68,000}$ or 1.47 calories per hour. For 0.1 c.c. that is, the volume considered above the heat production is 0.147 calories per hour, or $\frac{0.147}{0.000056} = 2600$ times greater than the energy supplied per hour during the treatment. The difference is much more striking if we consider that the

*Clinicians and pathologists must decide just what facts to record.

TABLE I

TABLE SHOWING SKIN DOSES IN TERMS OF ABSORBED ENERGY FOR DIFFERENT CONDITIONS OF APPLICATION

1	2	3	4	5	6	7	8
Applicator	*Size cm.*	*Distance cm.*	*Emanation mc.*	*Time hrs.*	*Millicurie-hours*	*Total micro-calories per cm.² x 1 mm.*	*Average micro-calories per hour*
Tray	4 x 5	3	500	4.1	2000	360	88
Pack	8 x 12	6	2000	4.6	9000	370	80
Pack	8 x 12	10	2000	9.3	20000	360	39
Block	4 x 6	4	1500	2.2	3200	340	150
Block	4 x 6	4	1000	1.6	1500	160	100
Cork	1.4 x 0.05	2	200	4.2	830	420	100

Filtration in all cases equivalent to 2 mm. of brass.

minute quantity of radiant energy which caused the tissue changes was applied at the rate of 56 microcalories per hour, for only a few hours. Also we assumed that the treatment was given by using 100 millicuries of emanation, while in practice we could probably use 10 mgm. of radium element* for a little more than eighty-three hours, and obtain the same skin effect. In this case the rate at which the radiant energy is supplied to the tissue is only about $\frac{1}{30{,}000}$th of the amount produced in the tissue, per hour. Of course the total amount is the same or a little more than in the previous case.

At the Memorial Hospital, for external treatments, several applicators of different shapes and sizes have been used for a long time. The skin doses for such applicators, therefore, are known quite accurately. Proceeding as for the above example, but including the effect of the distribution of the source (size and shape of the applicator) the amount of energy absorbed during the treatment by a layer of skin 1cm.^{2} x 1mm. was calculated for each applicator. The results are shown in column 2, Table I. For a proper interpretation of these results we have to consider them a little further. An irradiation of 2000 millicurie-hours with the tray applied at a distance of 3 cm. from the skin, and of 9,000 or 20,000 millicurie-hours with the pack at 6 or 10 cm., produces in practice substantially the same effect on the skin. That is, it produces a mild erythema on the skin of the average patient, a more severe reaction on patients who are abnormally radio-sensitive, and no visible reaction at all on the more resistant patients. The calculated values of the energy absorbed, 360, 370, and 360 microcalories respectively, show a remarkable agreement considering the large number of variables, both physical and biological, involved in the problem. It will be noticed that the shape and area of the applicators and the distance of application are quite different. The proper spacing in either case is obtained by a block of Balsa wood, which has approximately the same density as cork. The filter, (silver, brass, and wood) is such that the total filtration is equivalent to 2 mm. of brass plus a suitable secondary filter.[7] This has been found to be sufficient to give a penetrating radiation which is absorbed exponentially by tissue,—the desideratum for deep therapy.[6] The decrease of radiation with distance was determined from suitable curves which take into account the shape and size of the applicator.* When 3200 millicurie-hours are given with the block, the energy absorbed is 340 microcalories. But owing to the fact that this applicator has lead-lined brass sides to reduce overlapping when radiating adjacent areas, the energy absorbed

*If we used emanation for this treatment we would have to allow for the decay of the emanation during the long exposure.

*These curves, which are of general applicability, will be published in the near future.

by the skin is really larger than this value.* The clinical data at our disposal are not sufficient to enable us to compare the skin effects produced by this applicator on the average patient with the effects produced by the applicators previously discussed. The block is rarely used for isolated treatments, having been designed primarily for cross-firing the pelvis through three anterior and three posterior portals.[8] In this case it has been found that 1,500 millicurie-hours are sufficient to produce a slight erythema in the average patient. This is an interesting observation, showing that more than half the radiation which produces the effect on the skin is supplied by the applicators in other parts of the body, five additional block treatments as well as vaginal and uterine applications. For the tube the energy absorbed (420 microcalories) is more than for the tray at 3 cm. and pack at 6 cm., but the effect on the skin is also more marked. As a result of this analysis we may say that the observed effects on the skin of a very large number of patients and the calculated values of the energy absorbed by 1 sq. cm. of skin, 1mm. thick, for various conditions of application, agree closely; certainly as closely as we can expect under the circumstances. It should be noted, however, that the filtration is the same for all the applicators considered above.

At the present time we have not sufficient information to calculate the amount of energy absorbed by tissue when the quality of the radiation is very different. A good deal of experimental work will have to be done before we shall be able to do so. For this reason we do not know with certainty that the physiological effect of radiation depends on the amount of energy absorbed by the tissue, irrespective of the quality of radiation reaching the tissue. There is considerable indirect evidence tending to support this view, but the experimental data bearing directly on this point is not conclusive.†

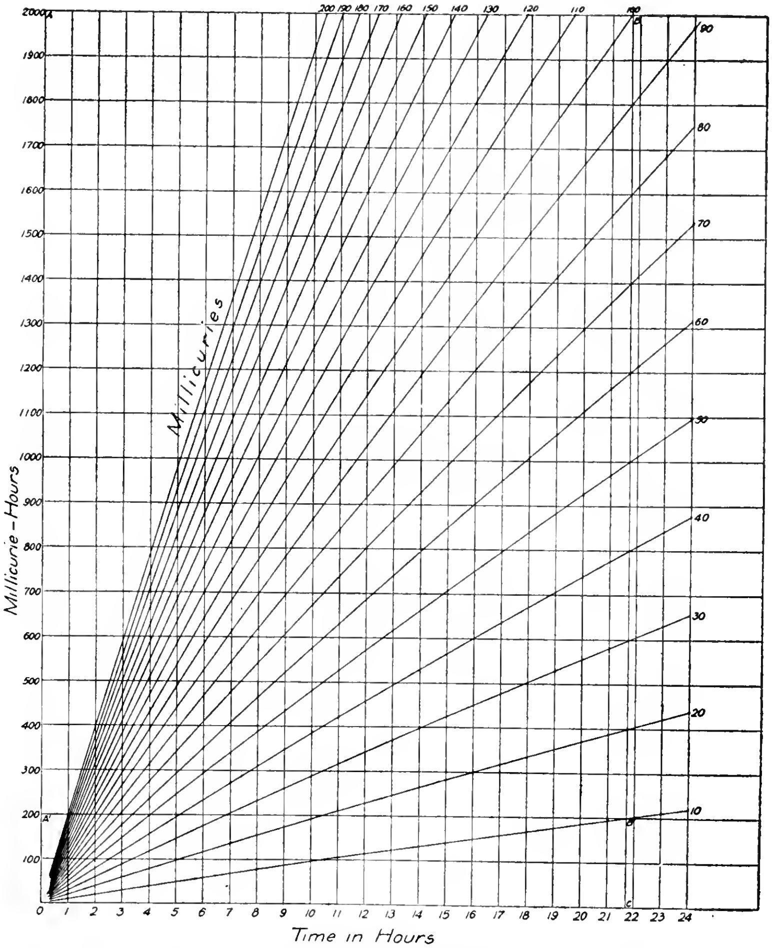
When this problem is solved, it will be possible to express doses of radiation for both x-rays and radium rays in terms of the energy absorbed by the tissue irradiated. We shall have then a rational system of dosage of quite general applicability.

A great many different units of dosage have been suggested, depending on different properties of the radiations. Attempts have been made to define a biological unit. Russ[9] suggested as the unit of dose the amount of radiation necessary to kill mouse cancer, which he determined experimentally. He called this unit the "Rad." Ghirlarducci[10] suggested the amount of radiation necessary to produce ulceration of the intestines of rabbits. The erythema dose has been extensively used as a unit of dose, especially in x-ray therapy. It may be said of all biological units that in the ultimate analysis they depend on physical measurements. It is the physical factors which are to be adjusted properly to obtain the desired result. We must know, therefore, how distance, filtration, time of exposure, etc., affect the dose.

For purposes of comparison we may take as a standard any distinct biological effect of radiation, e.g., skin erythema. It is very important to remember, however, that a biological effect produced by radiation cannot be used as a *measure* of the amount of radiation administered. Thus, if we make a radium application and produce a marked skin erythema, then double the time of exposure leaving the other conditions the same, we cannot tell from the degree of erythema alone that the dose has been doubled. Qualitatively we can tell that the second dose is larger than the first, but we cannot say how much larger. Biological observations of this type are unsuited for quantitative work. Furthermore, the more severe the reaction, the harder it is to distinguish between different doses. Under certain conditions, however, we can use the erythema dose as a standard of comparison. For this purpose the degree of erythema must be such that a decrease of 20 per cent or 25 per cent in the dose of radiation which produces a definite reddening of the skin, will result in no visible effect on the skin. That is, the degree of erythema chosen must be on the borderline between no visible effect and a definite effect. We need not consider the radio-sensitivity

*This statement is substantiated by experimental evidence.

†The agreement between the electroscope readings and the biological results for beta and gamma rays in Friederich and Kroenig's experiments is only accidental. For instance, if these authors had placed the source of beta and gamma radiation closer to the electroscope than one meter, there would have been no agreement.



of different patients and different parts of the body, because we can eliminate such differences by taking a sufficiently large number of patients for our determination of the *average* skin dose.

Having adopted a biological unit of dose, subject to the above-mentioned limitations, we express it in terms of the physical factors which affect it. Then we can give of this dose by a proper choice of these factors. For instance, with the tray applicator of Table I we know that we obtain a definite erythema on the average patient by using 2000 millicurie-hours at a distance of 3 cm., with a filter equivalent to 2 mm. of brass. If we give 4000 millicurie-hours under the same conditions we can say that we have given two erythema doses, although clinical observations alone do not enable us to tell that twice the amount of radiation was used. The necessity of referring doses of radiation to the physical factors of dosage, is even more apparent if we remember that there is a long interval between the time when the treatment is given and the time when the physiological effect manifests itself. We cannot adjust the dose according to the effect produced in the tissue because at the time of the treatment, and for a considerable time thereafter, there is no visible change.

It is generally hoped that eventually an instrument will be made by means of which we can measure the doses of radiation given, as we weigh drugs by means of a balance. While it is possible to make such an instrument, it is doubtful whether it can be so simple and reliable as to be available to the average physician. The author is of the opinion that, in reality, there is no necessity for such a measuring instrument for general use. It will not be very long before the laboratories which are best equipped for this work will have worked out tables and charts from which it will be possible to determine the amount of radiation delivered to the skin or tissue layer at any depth, in terms of a convenient unit, for any given conditions of application. Indirectly it will be possible to determine from these data the best practical method of treatment for any given case. These tables, of course, would not point out how to cure a patient, but would indicate the most efficient way to apply radiation considering the geometry of the diseased region. As to the amount of radiation to be administered to effect a cure, if a cure is possible, the individual physician would have to rely on his experience.

In this country it is customary to express "doses" of radiation in milligram-hours or millicurie-hours. A comparison of the values in column 6 and those in column 7 of Table

I shows immediately that this in itself does not at all represent the dose as measured by the effect on tissue. In column 6 there is a 22-fold variation in the millicurie-hours, while the values of column 7, which represent the skin doses, are nearly the same. And yet the method of treatment is the same, that is, gamma ray treatment by external applications at a distance from the skin. If we included other methods, such as buried emanation, or radium needles, the differences in milligram-hours for the same dose would be enormous. It is true that this fact is borne in mind by all those who make use of the notation. Nevertheless the result is that in general the other factors which are just as important in the complete specification of a dose, are not given due prominence. Furthermore, this notation introduces no simplification, because the duration of the treatment or the strength of the applicator must be stated separately. In Table I the factors which indicate the *intensity* of the treatment are given in column 8 expressed in microcalories absorbed per hour by 1 sq. cm. of skin 1 mm. thick. The part which the intensity of the treatment, or what amounts to the same thing, the duration of the treatment, plays in the results obtained is not definitely known at the present time. It is certain, however, that it plays some part, and should be taken into account.

The milligram-hour or millicurie-hour notation, while unsuited for expressing dosage, has some useful purposes in a limited sense. If different treatments are given under exactly the same physical conditions, but with a different number of millicurie-hours, the dose is proportional to this number, within wide limits of the time of exposure. In an institution where many patients are treated with the same applicator, in general the amount of radium or emanation in the applicator is never the same, owing to the exigencies of other patients. In such a case if the dose for an applicator is given in milligram-hours, the person who applies it can determine the time of exposure according to the strength of the applicator by a simple division. When radium emanation is used as the radio-active source and the time of application is very long, the calculation of the time from a knowledge of the millicurie-hours and the initial millicuries is more complicated on account of the decay of emanation during the treatment. Given any two of the three quantities, millicuries, hours, and millicurie-hours, it is possible to calculate the third by the aid of the integral calculus. The decay of emanation takes place according to the law:

$$E_t = E_o e^{-0.0075\,t}$$

where E_0 = initial amount of emanation in millicuries

0.0075 = decay constant of the emanation in (hours)$^{-1}$

t = time elapsed in hours since the value of the emanation was E_0

e = Naperian base of logarithms.

E_t = amount of emanation remaining after time t.

The millicurie-hours for an exposure T will be given by

$$\text{mc.-hrs.} = \int_0^T E_o e^{-0.0075\,t}\,dt$$

$$= 133\,E_o\left[1 - e^{-0.0075\,T}\right]$$

The use of this formula is not very convenient, but one gifted with sufficient patience can work out tables from which any one of the three quantities involved can be obtained rapidly if the other two are known. However, it is simpler to make a chart which serves the same purpose. (See chart, p. 679.)

Since the use of emanation is rather limited at the present time a complete explanation of the use of this chart would be out of place here. Besides, a physicist, who probably would be the one to use it, can work out the problem without further explanation. However, as an illustration, the following example will be worked out: It is desired to give 2000 millicurie-hours using a tube of 100 millicuries; what is the necessary time of exposure? We draw a horizontal line through the 2000 mc.-hr. point at A until it intersects the 100 mc. curve at B. From this point we drop a perpendicular to the lower scale, and on it we read at C the time in hours, that is 21.7 hours. It will be noticed that we can get the same result by using the 200 mc.-hr. point at A′ and the 10 mc. curve. This means that we can multiply or divide the millicurie-hour scale and the millicurie scale by the same factor (10 in this case) without affecting the result. Thus the range of the chart can be extended considerably.

It should be noted, however, that the hour scale cannot be altered, but the other two can be changed, provided they are changed in the same ratio. The chart can be used in a similar way to determine the initial value of emanation which it is necessary to use to give a certain number of millicurie-hours in a given time; also to calculate the millicurie-hours having given the initial millicuries and the duration of the treatment in hours.

TABLE II

Days

Hours	0	1	2	3	4	5	6	7
0	1.0000	0.8351	0.6973	0.5823	0.4863	0.4061	0.3391	0.2832
1	0.9925	8288	6921	5779	4826	4030	3366	2811
2	9851	8226	6870	5736	4790	4000	3341	2790
3	9777	8165	6818	5694	4754	3970	3316	2769
4	9704	8104	6767	5651	4719	3941	3291	2748
5	9632	8043	6717	5609	4684	3911	3266	2728
6	9559	7983	6666	5567	4649	3882	3242	2707
7	9488	7923	6616	5525	4614	3853	3218	2687
8	9417	7864	6567	5481	4579	3824	3193	2667
9	9346	7805	6518	5443	4545	3795	3170	2645
10	9276	7746	6469	5402	4511	3767	3146	2627
11	9207	7689	6421	5362	4477	3739	3123	2607
12	9138	7631	6372	5321	4444	3711	3099	2588
13	9070	7574	6325	5281	4411	3683	3076	2568
14	9002	7517	6278	5242	4378	3656	3053	2549
15	8935	7561	6231	5203	4345	3628	3030	2530
16	8868	7405	6184	5164	4312	3601	3007	2511
17	8801	7350	6138	5125	4280	3574	2984	2492
18	8737	7295	6092	5087	4248	3548	2962	2474
19	8670	7240	6046	5049	4216	3521	2940	2455
20	8605	7186	6001	5011	4184	3494	2918	2437
21	8541	7132	5956	4974	4153	3468	2896	2418
22	8477	7079	5911	4936	4122	3442	2875	2401
23	8414	7026	5867	4899	4092	3417	2853	2383

TABLE II (continued)

Days

Hours	8	9	10	11	12	13	14	15
0	0.2365	0.1975	0.1649	0.1377	0.1150	0.0960	0.0802	0.0670
1	2347	1960	1637	1367	1141	0953	0796	0665
2	2329	1945	1624	1357	1133	0946	0790	0660
3	2312	1930	1612	1347	1124	0939	0784	0655
4	2295	1916	1600	1336	1116	0932	0778	0650
5	2278	1902	1588	1326	1108	0925	0772	0645
6	2260	1887	1576	1316	1099	0918	0766	0640
7	2244	1873	1565	1307	1091	0911	0761	0635
8	2227	1860	1553	1297	1083	0904	0755	0631
9	2210	1845	1541	1287	1075	0898	0749	0626
10	2193	1831	1530	1277	1067	0891	0744	0621
11	2177	1818	1518	1268	1059	0884	0738	0616
12	2161	1804	1507	1259	1051	0878	0733	0612
13	2145	1791	1496	1249	1043	0871	0727	0607
14	2129	1777	1484	1240	1035	0864	0722	0603
15	2113	1764	1473	1230	1027	0858	0716	0598
16	2097	1751	1462	1221	1020	0852	0711	0594
17	2081	1738	1451	1212	1012	0845	0706	0589
18	2066	1725	1440	1203	1004	0839	0700	0585
19	2050	1712	1430	1194	0997	0833	0695	0581
20	2035	1699	1419	1185	0990	0826	0690	0576
21	2020	1686	1408	1176	0982	0820	0685	0572
22	2005	1674	1398	1167	0975	0814	0680	0567
23	1990	1661	1387	1158	0968	0808	0675	0563

TABLE II (continued)

Hours	Days: 16	17	18	19	20	21	22	23
0	0.0559	0.0467	0.0390	0.0326	0.0272	0.0227	0.0190	0.0158
1	0555	0464	0387	0323	0270	0226	0189	0157
2	0551	0460	0384	0321	0268	0224	0187	0156
3	0548	0456	0381	0318	0266	0222	0185	0155
4	0543	0453	0378	0316	0264	0220	0184	0154
5	0539	0450	0376	0314	0262	0219	0183	0153
6	0534	0446	0373	0311	0260	0217	0181	0151
7	0531	0443	0370	0309	0258	0215	0180	0150
8	0527	0440	0367	0307	0256	0214	0179	0149
9	0523	0436	0364	0304	0254	0212	0177	0148
10	0519	0433	0362	0302	0252	0210	0175	0146
11	0515	0430	0359	0299	0250	0209	0174	0145
12	0511	0427	0356	0297	0248	0207	0173	0144
13	0507	0424	0354	0295	0247	0206	0172	0143
14	0503	0420	0351	0293	0245	0204	0170	0142
15	0500	0417	0348	0291	0243	0203	0169	0141
16	0496	0414	0346	0289	0241	0201	0168	0140
17	0492	0411	0343	0286	0239	0200	0167	0139
18	0488	0408	0341	0284	0238	0199	0166	0138
19	0485	0405	0338	0282	0236	0197	0164	0137
20	0481	0402	0336	0280	0234	0195	0163	0136
21	0478	0399	0333	0278	0232	0194	0162	0135
22	0474	0396	0330	0276	0230	0192	0160	0134
23	0470	0393	0328	0274	0229	0191	0159	0133

An inspection of the formula

$$\text{mc. - hrs.} = 133\, E_0 \left(1 - e^{-0.0075\,T}\right)$$

suggests another method of attacking the problem. The factor 133 is a very important radioactive constant known as the "average life" of the emanation, 5.5 days or 133 hours. The quantity $E_0\left(1 - e^{-0.0075\,T}\right)$ represents the amount of emanation which has disintegrated during the time T, starting with an amount E_0 millicuries. Therefore the formula can be written—

mc. - hrs. = (average life in hours) (amount decayed n millicuries)

Evidently then if we know the number of millicuries of emanation which disintegrated or decayed during the treatment, the millicurie-hours can be obtained by multiplying this number by 133. To determine the millicuries disintegrated, we can make use of Table II, part of which was originally calculated by Kolowratt.[11] This table is very useful, primarily because it enables us to tell at a glance the value of a tube of emanation at any time after it has been measured.[12] For this purpose it can be used in two ways depending on the accuracy required. An example will make these clear. A tube of emanation is measured on Monday at 2:00 p.m., and is found to contain 254 mc. What will be the value of the tube the following Wednesday at 10:00 a.m.? The elapsed time is one day and twenty hours. From the table we find that 1 mc. will be reduced to 0.718 mc. in one day, twenty hours. Hence 254 mc. will be reduced to 254 x 0.718 = 182.3 mc. We can get approximately this value directly from the table as follows: It will be noticed that the decimal point does not affect the relative values of the figures in the table. We can find in the table a figure which is very close to 254, that is 0.2549. Then counting one day twenty hours beyond this point we find the figure 0.1831. Therefore the value of the tube is 183.1 mc. which is very close to 182.3 mc.

If this tube had been used on a patient for one day and twenty hours we could calculate the millicurie-hour exposure as follows: Initial value, 254 mc. Value at end of treatment, 182.3 mc. Millicuries destroyed,

$$254 - 182.3 = 71.7 \text{ mc.}$$

$$\text{mc. - hrs.} = 133 \times 71.7 = 9540.$$

The average value of the emanation tube during the treatment was

$$\frac{9540}{24 + 20} = 217 \text{ mc.}$$

So if a radium tube were to be used to give the same treatment in the same time, its radium content should be 217 mgm.

In France, and especially at the Curie Institute in Paris, a slightly different notation

is used than in the United States. Instead of millicurie-hours, the "millicuries destroyed" (mcd) during the treatment are used to represent the amount of radiation produced by the radioactive source. This notation was first suggested by Debierne and Regaud[13] in 1914. Lately Regaud and Ferroux[14] have elaborated this further and introduced in addition the millicuries destroyed per hour $\mu c \delta$ to indicate the intensity of the treatment. This notation has no real advantage over the millicurie-hour notation as is evident from the fact that mc.-hrs. $= 133$ (mcd). The figures given in millicuries destroyed are simply 133 times smaller than those given in millicurie-hours. Evidently a factor of proportionality (133) cannot alter the notation in its essential features. The authors claim the advantage of uniformity because whether radium salt or emanation is used for the treatment, the radiation produced in either case can be expressed in millicuries destroyed instead of milligram-hours or millicurie-hours. However, on account of the fairly rapid rate of change of the emanation, which in very long treatments (e.g. buried emanation) has an effect on the result obtained, they find it necessary to state whether radium salt or emanation is used for the treatment. They do this either explicitly or implicitly by giving, in the case where emanation is used, the average strength of the source or the average number of millicuries destroyed per hour during the treatment. In our notation if we say milligram-hours, it is evident that radium was used, whereas millicurie-hours refers to emanation. However, it must be said that the expression "millicuries destroyed" (or millicuries "used up") has a certain appeal to the physicist because it brings to mind the atomic processes by which the radiant energy is obtained. There is no likelihood that the notation will find favor in this country, but, since it is used abroad, we should be familiar with it for purposes of comparison. The papers referred to describe it fully. It is also discussed by Mme. Laborde in a recent book on radium therapy.[15]

In calculating the values of the energy absorbed by tissue as given in Table I, we have taken into account the factors 1, 2, 3, 4, and part of 5 of the physical conditions of the treatment. To include 5 completely we must consider special cases in which the relative positions and distances of the source of radiation, pathological tissue and normal tissue are accurately known. In general, however, these conditions are known only approximately. To bring out their importance Table III has been worked out. If we give the same erythema dose or any fraction or multiple thereof, with all the applicators of Table I, we can call the dose on the skin 100 per cent in each case. Calculating on this basis the doses at different depths of tissue, taking account of the shape and size of the applicator, the filtration, the distance and the absorption by tissue, we find that the doses at any depth below the surface are quite different for the various applicators. This knowledge is of importance in selecting a method of attack and the proper applicator for the treatment of a given lesion* It should be borne in mind, however, that at the present time we cannot make effective use of this information because we do not know with any degree of accuracy the relative susceptibility to radiation of the pathological tissues in a given lesion and the normal tissue around it. But it can be used to determine just the very thing we do not know. For example, let us assume a nodule which we estimate to be 1 cm. in diameter and 1 cm. below the surface of the skin. We give the following treatment: 2000 mc.-hrs., using 500 mc. of emanation, the brass tray of Table I, equivalent filtration, 2 mm. brass; distance, 3 cm., and we find that the nodule disappears. In this case we estimated the tumor to be between the first and second centimeter of tissue from the skin surface. From Table III for the tray we find that the dose for the nearer side of the tumor was 57.9 per cent and for the farther side 36.6 per cent of the skin dose, which injures the skin hardly at all. The disappearance of the tumor shows that the pathological tissue in this example must have been at least three times as sensitive as the normal tissue surrounding it. Now if in another case we find another nodule which, as far as we can tell, has all the clinical and pathological characteristics of the first one but is located between the sec-

*In practice data of the type shown in Table III are needed for all the applicators in use, tubes, needles, etc.

ond and third centimeters below the skin, we are justified in assuming that the same dose of radiation as before *delivered to the tumor* will cause its retrogression. From Table III we see, however, that the tray applied as in the previous case will not give us sufficient radiation at a depth of 2 to 3 cm. for the same skin effect as before. We need not discuss all the methods by which we can obtain a sufficient dose at this depth. It is evident, however, that the pack at 6 cm. used according to the data of Table I, will deliver a little larger dose of radiation to this tumor than the dose delivered to the first tumor by the tray application. If our assumptions as to the clinical and pathological identity of the two tumors are correct, the second nodule should also disappear. These examples illustrate the necessity of keeping accurate records so that sorely needed and very important information concerning the effects of radiation on tissues can be collected. The problem is much more difficult than it seems from these examples, but eventually it will undoubtedly be solved.

TABLE III

TABLE SHOWING RELATIVE DOSES OF RADIATION REACHING DIFFERENT DEPTHS OF TISSUE FOR VARIOUS CONDITIONS OF APPLICATION

Applicator	Depth below Skin			
	Surface	1 cm.	2 cm.	3 cm.
Tray	100	57.9	36.6	24.4
Pack (6 cm.)	100	72.8	54.3	40.8
Pack (10 cm.)	100	79.6	62.6	50.0
Block	100	63.5	42.6	30.0
Cork	100	42.0	21.7	12.9

SUMMARY

In this paper it is suggested that doses of radiation be reckoned according to the amount of energy absorbed by the radiated tissue. The latter includes not only the pathological tissue which we are trying to obliterate but also the normal tissue surrounding it which we must not injure unduly. The success of the treatment depends on the *relative* amounts of radiation absorbed by healthy and diseased tissue as well as on the *absolute* amount of radiant energy absorbed by the pathological tissue. The *intensity* of a treatment, which may be measured by the duration of the exposure or the strength of the radioactive source, is not without influence on the final result and must be taken into account.

The physical constants which enter into the complete specification of a dose are:

1. The strength of the radioactive source.
2. Its distribution.
3. The total filtration used.
4. The duration of the irradiation.
5. The relative positions and distances of the source of radiation, pathological tissue and normal tissue.

Having the above data we can express the dose in any unit we please. Since the biological effect must be due to the radiant energy absorbed by tissue, it is suggested that this be taken as measure of the dose administered and that it be expressed in calories.

At the present time it is not possible to express doses in calories for all forms of radium treatment, because some of the data necessary for such calculations are not available. The same data are needed for a proper interpretation of clinical results and therefore it is very important to carry on experiments leading to the solution of this problem.

Some examples given in this paper show the advantage of the method of dosage suggested. Doses of gamma radiation given with various applicators at different distances from the skin, which produce the same degree of erythema, are the same when expressed in calories but very different when expressed in milligram-hours. The latter notation can be used only to represent the amount of radiation *emitted* by the radio-

active source but not to represent that part **of** the emitted energy *utilized* during the **treatment,** which is really *the dose.*

Once we have established a system of dosage based on the effective radiation at any depth of tissue, we can use to better advantage the knowledge obtained from the treatment of patients. The difficult problem of determining the necessary and sufficient doses for different pathological conditions is greatly simplified. It should be noted, however, that even though we may know the amount of radiation necessary to destroy a certain tumor, and can administer it, it does not follow that the patient will get well. If a mistake is made in estimating the extent of a lesion this will result also in giving an insufficient dose. Therefore, a good knowledge of cancer is essential for the successful application of radium.

The method of dosage for radium therapy suggested in this paper can be used for x-ray therapy as well.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

THIRD ANNUAL MEETING
EASTERN SECTION, THE AMERICAN ROENTGEN RAY SOCIETY
ATLANTIC CITY, N. J., JANUARY 26, 27, 28, 1922.
Headquarters, Meetings and Exhibits, Ritz-Carlton Hotel

EDITORIAL

In presenting the picture of our Ex-President, Dr. Baetjer, in this number of the Journal, we are prompted thereto by the opinion voiced by all members of the American Roentgen Ray Society at the last Annual Meeting held at Washington, D. C., that in addition to the dinner which was given in his honor, his picture should appear in the Journal, thus commemorating in a double way the esteem in which he is held by the Society.

THIRD ANNUAL MEETING OF THE EASTERN SECTION, A. R. R. S.

The Third Annual Meeting of the Eastern Section of the American Roentgen Ray Society will be held at the Ritz-Carlton Hotel at Atlantic City on January 26, 27 and 28th.

It will be observed that a day has been added to the length of the meeting this year. The first session will be held on Thursday evening at 8:15. There will be morning, afternoon, and evening sessions on Friday, and a morning and an afternoon session on Saturday, with a dinner-dance Saturday evening.

The manager of the Ritz-Carlton promises to take care of everyone desiring to attend the meeting, and will make every effort to make the stay a pleasant one. The rates will be $10 per day, *American plan*, for individual rooms with a bath, and $18 per day, *American plan*, where there are two in a room. For those not desiring meals in the hotel special rates have been secured on the European plan, as follows: Single room and bath, $5.00; double room and bath, $7.00. Reservations should be made as early as possible and be sure to state that you are attending the meeting of the Eastern Section of the American Roentgen Ray Society.

Visitors who are not members will be just as welcome this year as they have been in previous years. Visitors are requested to register in order that preparations can be made for their care.

An attractive program is nearly complete and will be published in the next issue of the Journal.

The Lantern Slide Exhibit which has been such a successful feature of previous meetings will be held again. Those having interesting slides which they wish to show should make application for a place on the program. Write to the President and state the number of slides which you wish to show.

An added feature of the meeting this year will be the dinner-dance which will be given on Saturday evening. Members and visitors are requested not to forget this feature and be sure to bring the ladies.

Don't Forget the Dates, January 26th, 27th, 28th.

President, J. M. Steiner, M.D.,
103 Park Ave., New York City

Vice-President, H. M. Imboden, M.D.,
480 Park Ave., New York City

Secretary, C. A. Waters, M.D.,
1100 N. Charles St., Baltimore, Md.

Arrangements are also being made for a commercial exhibit, which was so successful last year. Correspondence regarding this feature should be addressed to Paul B. Hoeber, Business Manager, 67-69 East 59th St., N. Y.

IMBEDDING RADIUM THROUGHOUT DIFFERENT PARTS OF THE BODY IN MALIGNANCY

THERE are four important methods by which large quantities of radiation can be given at a considerable distance from the surface of the skin. The first, and probably the best method, is by imbedding a number of radium needles throughout the organ involved, as well as in the adjacent glandular tissues; second, by using heavy filtered roentgen rays through a number of ports of entry, as has been adopted by most radiologists; third, by using heavy filtered roentgen rays, exposing large skin areas, employing very high voltage, which is now known as the new German technique, and fourth, by applying a pack of radium tubes, properly spaced, the pack to be from 10 to 15 cm. square in order to give off a large amount of secondary rays, the same as when large areas are treated by roentgen rays and at sufficient distance so that the loss by divergence is not too great. By both of the latter methods it is necessary to use large ports of entry, because we depend upon the secondary radiation in the tissues as well as upon direct radiation.

One of the greatest mistakes made by radiologists has been that they have given a superficial erythema dose when a lethal, or cancer-destroying dose should have been given to destroy all cancerous cells. This is difficult by any method.

During the past year, there has been more discussion and investigation in regard to the best form of radiation that will destroy malignant tissue of all types, both superficial and deep, and the best technique of giving a lethal dose to cancer cells, than there has been during the past fifteen years. The physical laboratories are working along this line, pathologists are taking more than a passing interest, the surgeons are realizing the importance of radiotherapy, all specialists are interested, and there are a great many physicians who are devoting their entire time to this subject. Unfortunately there are many purchasing radium and giving roentgen-ray treatment who are not qualified and never will be. It is extremely unfortunate that the medical profession should do such kind of work, whether it is for commercial reasons or through ignorance.

A large number of physicians doing radiotherapy, are not paying sufficient attention to technique to accomplish the best therapeutic results. Where untoward results are obtained from radiation, it is invariably the result of bad technique. An insufficient dose applied to a refractory tumor may excite its development. An excessive treatment may also harm and subsequently retard the cure of the tumor.

Different types of neoplasms and different types of healthy cells vary in their sensibility to radiation, but a determined type of cell in a determined part of the body has always practically the same sensibility. Glandular tissue is more sensitive than epithelioma, and epithelioma is more sensitive than muscle. The different neoplasms differ greatly in their sensitiveness to radiations, but, within certain limits, each tumor responds in a characteristic way to radiations, following its nature, its location and the period of its involvement. The same type of cells at times behaves differently, according to the different kinds of radiation employed. What we aim at in radiation is to destroy neoplasm without destroying the adjacent tissue. This is probably best acomplished by burying radium needles.

Radium has justly achieved a good reputation in the treatment of cancer. Probably its greatest field of usefulness is in preparing a malignant area against wound-grafting and, at least temporarily, to reduce the vitality of the cancer cell. Radiation, applied either as radium or roentgen rays, destroys malignant cells beyond the area of destruction. During the reaction from radium treatments the cells undergo retrogression, their resistance is reduced, and operation can be performed with greater efficiency, but operation should be delayed until active radiation has taken place. By properly combining radiotherapy and surgery, we can increase the number of cures and lower the mortality. Radiation sterilizes cancer cells at a greater distance than any other method and connective tissue is formed which acts as a barrier to the further extension of the malignant process.

Ability to classify the cases forms an important part of the training of the radiolo-

gist. The question of large dosage altering normal tissue after the reaction has disappeared is well known and this alteration of tissue will not permit the normal tissues to bear so well a second exposure. Normal tissues are usually more easily injured by a repetition of the radiation, while the cancerous tissue may not retrogress in a proportional degree. In fact, the cancer cells and normal tissue may react in about the same degree, or there may even be a reversal of the primary susceptibility of the tissue. This suggests giving the maximum dosage at the first treatment and the removal, either surgically or by electro-coagulation, of the overlying normal tissue, which has reached ray toleration, before more treatment is given.

In the removal of a tumor, tissues may be incised which contain microscopic cancer cells, and at a time when the lymphatic spaces are wide open and the cancer cells are easily grafted into the surrounding tissues. But if these cells are rendered immune, a relapse cannot occur, except it arises from cells of the tumor actually living before they have received a sufficient dose of radiation, and the possibility of such a relapse demands a subsequent prophylactic treatment.

I have discussed and corresponded with various radiologists in regard to imbedding radium needles, but the information received makes it practically impossible to draw any general conclusions. The time of exposure and the distance of the needles apart vary considerably, but nearly all agree that imbedding radium in malignant tissue is superior to surface applications in many locations. Some advise placing radium needles 1 cm. apart, while others advise a distance of 2½ cm. between the needles. One operator gave two or three hours' exposure, while others gave between eight and twelve hours' exposure, using the same amount of radium element in each tube and at the same distance apart, and practically nothing was reported in regard to the reaction in the tissues. I have adopted as a standard method placing 10 mm. needles 1 cm. apart in the tongue or tonsils, and have been giving from three to eight hours' exposure. This produces some inflammatory reaction, but in no case has marked necrosis taken place, except in one or two cases, situated in the buccal mucous membrane where the tissue was about to break down or has broken down before the treatment was begun. An epithelioma of the buccal mucous membrane will stand only one-third as much radiation as that of the tonsil or tongue. The mucous membrane of the rectum or bladder is much more susceptible than that of the vagina.

The method which we have been employing in the treatment of carcinoma of the breast is as follows: Give surface treatment of either roentgen ray or radium through as many ports of entry as possible. Two to three weeks later we have been imbedding as high as 25 or 30 needles throughout the breast, through the axilla and throughout the glands leading from the breast to the clavicle. This subject was discussed and I have published in detail the manner and technique of inserting the needles (*American Journal of Roentgenology,* January, 1921).

In connection with this method of radiation, I report the following cases:

Case I. Mr. C. was referred with an inoperable carcinoma of the left tonsil. He was first given surface application of radium on the left tonsillar region, and the cervical glands on both sides of the neck were thoroughly rayed with roentgen rays and radium. One month later 16 (10 mgm.) needles were inserted into the tonsil, pharyngeal wall, base of tongue and the glands at the angle of the left jaw for three hours. At present the case is clinically cured.

Case II. Mr. S., with an inoperable carcinoma of the left tonsil involving the palate, base of tongue and cheek, was in very poor physical condition and was brought to the hospital in an ambulance. Sixteen 10 mgm. needles were inserted for three hours. Some improvement was shown at first, but this process was entirely too extensive to expect more than palliation.

Case III. Mrs. B. was referred by a prominent surgeon who refused to operate for a carcinoma of the right breast. She had a mass in the breast as large as a lemon, and the axillary and supraclavicular glands were involved. She had a very complete course of roentgen-ray treatment. Five weeks later twenty-five 10 mgm. needles were inserted in the breast and adjacent tissues. She is clinically cured, but there is a small fibrous nodule left in the breast.

Case IV. Mrs. S. was referred with

Paget's disease of the right breast. The needles were used in this case similar to the others and the disease of the nipple has entirely disappeared.

Case V. Mrs. S., aged sixty-four, was referred with a sloughing epithelioma of the right vulva. Twenty 10 mgm. needles were inserted three weeks ago. She has greatly improved.

Case VI. Mr. C. was referred with carcinoma of the stomach. His physician insisted upon his having radium. Fifteen thousand mgm. hours were given on the abdomen, a pack 15 x 15 cm. square containing 1 gm. of radium, at 4 cm. distance. This patient when first seen was bed-fast. At the present time he is up and walking around, has a good appetite and feels fine. Of course, a cure is not expected.

Summarizing, it is aparent that the effort to attain curative results in the treatment of cancer by ray therapy will only be successful when adequate methods of treatment are developed. In our present ignorance of the exact nature of malignant growths, and with the apparent fact that the radium and roentgen rays are effective in the destruction of malignant growths only when a lethal dose of the rays reaches all the malignant cells, it follows that the best technique for the application of these rays is that which will most satisfactorily approximate a homogeneous irradiation with the necessary ray dose. This will in general not be the simplest technique, and often will involve a combination of methods. With radium the necessary dose can be given, using the minimum quantity of radioactive material and with the least destructive effect on adjacent normal tissues, by the insertion of multiple sources of the rays into the tumor mass. When adequate quantities of radium are lacking to control extensive regional involvement, the use of massive doses of heavily screened roentgen rays through large ports of entry seems to offer most.

Russell H. Boggs.

BOOK REVIEWS

Mastoids, Roentgenologically Considered, by Frederick M. Law, M.D. Annals of Roentgenology, a series of Monographic Atlases, edited by James T. Case, M.D. Volume 1, containing 42 x-ray studies on 21 photographic plates and 11 text illustrations, 39 pages of text in English, French and Spanish of the plates. Price $16.00. Paul B. Hoeber. New York, 1920.

This monographic atlas serves to bring to the roentgenologist a post-graduate course in the roentgenological diagnosis of diseases of the mastoid. It contains a series of master roentgenograms with which useful comparisons can be made by the roentgenologist as often as desired. These contact prints are positives from the original negatives in order to lose as little detail as possible, and every one is a triumph of roentgenographic and photographic skill. Types of normal mastoids are described, following which pathological mastoids are discussed. The technique for getting good views of the mastoids is well described and fully illustrated. For fine detail the author prefers a gas tube with a current of 30 to 40 ma., and an equivalent spark gap of 5½ inches for five seconds and a distance of 18 inches with 2 mm. of aluminum filter.

The plates which illustrate simple acute mastoiditis are very characteristic. Perisinuous abscess, cholesteatoma, and cyst of the mastoid are depicted so as to teach a roentgenologist to be able to recognize these conditions when he is not familiar with them. Undeveloped infantile, chronic mastoid, and postoperative mastoids are also very well illustrated.

The book is of the high standard set by the Annals of Roentgenology and is especially valuable to roentgenologists attached to general hospitals.

A. H. Pirie

TRANSLATIONS & ABSTRACTS

Warnekros. Pregnancy and Labor in Roentgen Pictures. (*Ztschr. f. Geburtsh. u. Gynäk.*, 1918, lxxx, 719. *Am. J. Obst. & Gynec.*, 1920, i, 318.)

Advance in technique has made it possible to procure exact pictures of the fetus within the uterus by means of very short exposures of about eight- to nine-tenths of a second. By preparing series of pictures of the same patient in the course of pregnancy, and especially during the actual process of labor Warnekros was enabled to obtain "by direct observation" definite information concerning the normal attitude of the fetus during pregnancy, and what seems more important concerning the mechanism of labor. Warnekros with some justification demands that wherever such observations do not harmonize with older views or theories, the latter must now be discarded as positively disproved. In regard to the normal attitude of the fetus he concludes: In the absence of a mechanical disproportion between fetus and uterus, and in the absence of any material or fetal abnormalities, the fetal head is held in a comfortable middle flexion. The fetal vertebral column in its convex bent is but conforming to the elliptoid shape of the uterus. There is also no forced or even typical attitude of the extremities. Their position depends solely upon the available space. This is true both for head and breech presentations. Any deviation from such a natural attitude suggests an anomaly of some sort. Even late in labor the fetus may change its position. The older conception that the presentation is dependent upon the stature of the mother is confirmed.

A thorough revision of views is required in regard to the mechanism of labor. Under normal conditions the head enters the pelvic canal without further increase in flexion. The extreme flexion occurs approximately at the time when internal rotation begins. This exaggeration of flexion clearly is the result of the pressure transmitted from the fundus by way of the vertebral column, which pushes the occiput deeper down. The vertebral column straightens while the head passes through the pelvis. Internal rotation apparently occurs, as is generally taught, under the influence of the pelvic floor muscles. At the moment when the head is born, in contradiction to common opinion, the shoulders are still seen to stand transversely in their normal relation to the head. There is no torsion. The thorax is circularly constricted and drawn down in a funnel shape. These findings possibly corroborate the older view that the first inspiration is effected by the spontaneous expansion of the compressed thorax.

(This article contains but a few of the many excellent radiograms which have been published in form of an atlas by J. F. Bergmann.)

Judd, E. S. Jejunal Ulcer. (*Surg.,Gynec. and Obst.*, August, 1921, xxxiii, 120.)

Gastrojejunostomy offers good prospect for permanent relief of symptoms in gastric or duodenal ulcer. In gastric ulcers excision of the ulcer should be performed in addition to the gastrojejunostomy.

Unsatisfactory results are most often due to performance of gastrojejunostomy when no ulcer exists. The operation should be performed only when the ulcer can be demonstrated beyond doubt.

Jejunal ulcer is one of the most serious and common complications of gastro-enterostomy. It may occur in the line of anastomosis as a gastrojejunal ulcer or below as a true jejunal ulcer. It is usually single, but may be multiple in the line of anastomosis. Edema and adhesions to surrounding tissues are marked. The lesion in the mucosa is limited to the intestinal side and is nearly always in the efferent loop.

It is doubtful if jejunal ulcer is ever primary, but if so it is exceedingly rare. The principal cause of secondary ulceration is undoubtedly the action of the acid secretion on the mucosa of the jejunum. Permanent suture material has also been a factor.

The author tabulates and analyzes 101 cases of jejunal ulcer following gastroenterostomy.

Clinical Manifestations.—Time of onset of symptoms varies from almost immediately after operation to eight or ten years. Pain is usually described as lower in the abdomen and more to the left than before operation; no

periodicity and not such complete relief by food or alkalies. In a certain percentage of cases the ulcers become adherent to the colon and perforate into it.

Diagnosis.—Jejunal ulcer is to be suspected when a recurrence of symptoms takes place after a period of relief following gastro-enterostomy for ulcer. Roentgen-ray examination offers the most accurate method of differential diagnosis. It must be differentiated from reactivation of the original ulcer, the development of malignancy, and inflammation of the appendix or gall-bladder. Several illustrations are given showing the deformity at the stoma and the narrowing of the jejunum due to the presence of ulcer.

Treatment.—Prophylactic treatment consists in avoiding trauma and the use of non-absorbable suture material, careful attention to the after-care, especially diet, and elimination of sources of infection elsewhere in the body. Surgical treatment consists in undoing the gastro-enterostomy, excising the jejunal ulcer, closing the openings in stomach and intestine, excising the original ulcer, and, if it seems best, doing a plastic operation on the pylorus. It is sometimes necessary to perform another gastro-enterostomy, but this should be avoided because of the liability of other ulcers forming.

Kohlmann, W. Radium in Carcinoma of the Uterus. (*Surg. Gynec. and Obst.*, August, 1921, xxxiii, p. 158.)

The possibility of a new method of treatment of uterine cancer with better results has been generally welcomed because of the unsatisfactory results achieved by surgery in this disease.

The author discusses the questions whether radium should be used only in inoperable cases and after surgery has failed; whether it should be used as an adjunct to surgery, or whether it should be given the preference as the only treatment, without surgical assistance.

In inoperable carcinoma radium treatment is accepted as the treatment of choice. Its value in recurrent carcinoma after panhysterectomy is only slight.

Pre-operative radiation should have value but it should be followed by operation not later than four weeks. The author employs radium postoperatively as routine treatment. Great care is necessary in the application of radium due to the proximity of the bladder and rectum.

Thus far, there is no uniformity of opinion as to whether radium should be the treatment of choice in early and operable carcinoma. The author cites the results in a few early cases where surgery was contraindicated because of the presence of complicating disease and in which he used radium alone. "The results in these cases have been in the highest degree satisfactory, and so far the most extensive surgical operation could not have produced results to surpass those obtained." There was one exception to this in a case which had a fulminating recurrence and died as a result of hemorrhage, but this case was complicated with diabetes.

The writer warns against giving the impression that radium is a sure and permanent cure in advanced cases. Much work must yet be done to determine how far-reaching is the effect of radium.

The effect of radiation in carcinoma can be noted in a few days after application. Infiltration and tumefaction of the cervix are soon diminished and this is followed by shrinking of the mass and infiltration of the broad ligaments.

The writer cites his experience in 12 cases treated by ligation of the internal iliac and ovarian arteries prior to radiation. He also describes his experience in the treatment of 96 cases, almost all of which were of a very advanced type. The palliative results in these cases were remarkable. He states that cases which did not show improvement after one or two treatments have not been influenced even by prolonged treatment. Further application in recurrences following an apparent cure by radium is usually without effect.

Technique of radium application is as follows: Silver tubes 1½ mm. thick, each containing 25 or 50 mgm. of radium are covered by a soft rubber finger cot, the end of which is tied. This is placed in the crater which is usually present in advanced cases and allowed to remain twelve hours. The vagina is packed with sterile gauze in order to protect the rectum and bladder. After one application the mass usually shrinks and a second application is made intracervically. Fifty mgm. covered by a celluloid capsule are placed in the cervix and 50 mgm. in the still existing crater or up-

per part of the vagina. Patient returned in from four to six weeks and, if improvement had taken place and some infiltrated tissue was still present, applications were repeated. If no improvement was observed, further treatment usually was without effect. During the past year Kohlmann has varied his technique with satisfactory results. The time of the first application is prolonged to twenty-four hours and repeated after six weeks.

Frankl, O., and Amreich, I. The Histological Changes Incident to Radium and X-Ray Treatment of Uterine Carcinoma. (*Surg., Gynec. and Obst.*, August, 1921, xxxiii, p. 162.)

The authors attempted to learn at what time the action of radium or *x*-rays is greatest and the point at which the effect begins to lessen by study of serial sections of excised tissue taken at different intervals from the crater and its edge in uterine carcinoma.

PROCEDURE

Radium.—A series of five treatments was given covering a period of twelve hours at intervals of one to two days, using 50 mgm. of radium in a platinum or brass filter with 1 cm. cotton and rubber.

X-Ray.—Focal distance 22 cm. Maximum dose of 18 H. units filtering through 3 mm. of brass and 0.5 m. of zinc, wood or chamois four times as thick; 3 ma., 11 Benoist, forty minutes per field. Three fields in front, four in back, and one in perineal region. A second series was given after six weeks.

They conclude from their observations that the areas directly exposed to the rays showed the first changes on the third and fourth days; that the influence of the rays was greatest between the fifth and seventh days; and that the rays were no longer effective after the fortieth day, when the genoceptors of the cells became active and caused proliferation. Areas indirectly treated were slower in showing changes and the effect soon wore off. The same histological changes were found in *x*-ray and radium treatment: first, edema, then enlargement of the cells and penetration of lymphocytes into carcinoma nests, and vacuolation. The changes took place sooner after *x*-ray than after radium treatment, and in *x*-ray treatment the stage of swelling of the cells is omitted. The writers believe this stage of swelling is undesirable in treatment, since it seems to be a form of cellular regression which does not lead to cell destruction.

Peterson, R. The *X*-Ray after the Inflation of the Pelvic Cavity with Carbon-Dioxide Gas as an Aid to Obstetric and Gynecologic Diagnosis. (*Surg., Gynec. and Obst.*, August, 1921, xxxiii, p. 157.)

The author summarizes his paper as follows:

1. The uterus together with the tubes and ovaries can be clearly shown by pneumoperitoneal roentgenography.
2. Owing to their distention with gas the tubes are rather more clearly demonstrated by the *x*-ray where inflation has been brought about through the transuterine route than where the inflation has been made transperitoneally.
3. On account of the rapid absorption of carbon-dioxide gas with equally rapid subsidence of the discomfort produced by the inflation, this gas should be used in preference to oxygen, which is very slowly absorbed.
4. Irregularities of the uterus, omental and bowel adhesions are clearly demonstrated by the pneumoperitoneal *x*-ray.
5. In not a few instances the diseased and enlarged appendages are more clearly made out by pelvic roentgenography than by the most careful and searching bimanual examination even under anesthesia.
6. With the improved position (knee chest and Trendelenburg) smaller and smaller quantities of gas will be necessary for inflation. Thus discomfort will be reduced to a minimum.
7. If the technique of pelvic roentgenography be good, retention of bowel coils in the pelvis will be proof of adhesions.
8. The pneumoperitoneal *x*-ray is able to demonstrate pregnancy at a much earlier period than is possible by the examining finger.
9. With good technique and good judgment in the selection of cases, both transuterine and transperitoneal gas inflation are free from danger.
10. Bimanual pelvic examination and pelvic pneumoperitoneal roentgenography are not antagonistic diagnostic methods. Each is valuable and their value is enhanced if they be used in conjunction, each acting as a check upon the other.

Ivy, A. C. Studies on Gastric and Duodenal Ulcer. (*J. Am. M. Assn.*, December 4, 1920, lxxv, 23.)

This experimental study on gastric and duodenal ulcer bears out the previous contention of the author that two factors are necessary for the experimental production of ulcer. First, the temporary or permanent lowering of the body resistance, and second, a temporary pathological mucous membrane manifested by hypo-acidity or achylia. He demonstrates that exposure of the mucous membrane of the pyloric antrum to the exterior causes no anatomical or physiological change even after ten months' exposure. Manipulation of an acute ulcer and mucosa of the pyloric antrum causes a delay in the healing amounting to from two to three times the normal healing time. The healing time of an acute ulcer of the mucosa in a healthy dog is not influenced by direct exposure to infection. Duodenal ulcer occurs in a dog accompanied by emaciation, vomiting, cachexia following gastroduodenostomy. The ulcers are located along the course of the blades of the clamp, and not at the suture line. He calls attention to the possible injury resulting in the use of the gastro-enterostomy clamp as related to the origin of jejunal ulcer.

W. W. Belden.

Palefski, I. O. Intubation and Visualization of the Duodenum with the Duodenal Tube. (*J. Am. M. Assn.*, December 4, 1920, lxxv, 23.)

This article is a further discussion of the one which was published in 1914 describing the technique and visualization of the upper intestinal tract by the conjoint use of the duodenal tube and the roentgen ray for the purpose of studying the course of the entire duodenum and the commencing jejunum. It further emphasizes that by this method displacements and angulations of the duodenum as a result of periduodenal adhesions can be detected. It is not always possible by the usual fluoroscopic and roentgen methods. After the duodenal tube has been passed, several specimens of the duodenal contents are obtained for the physical, chemical and microscopic examinations. The tube is then filled with a suspension of barium and plates are taken both erect and prone. The course taken by the duodenal tube along the lesser curvature of the stomach, in the duodenum and in the commencing jejunum, is shown as a horseshoe-shaped curve. The curve along the lesser curvature is normally about 2 to 3 inches above that of the transverse part of the duodenum. In periduodenal adhesions and in pyloric adhesions the course of the tube is usually altered. The patient is then allowed to drink half a glass of barium suspension and plates are again made in both positions. He states that the x-ray tube must be at right angles to the patient and the latter placed flat against the plate. He arrives at the following conclusions, namely, that the duodenal tube offers the best means of visualizing the course of the duodenum. Failure of the tube to pass beyond the first portion of the duodenum within four hours, he regards as indicative of spasm or organic obstruction. Further, the "duodenal tug" and obtained duodenal contents are not always reliable as a means of localizing the tube in the duodenum. High acidity, blood in the duodenal contents and a normal duodenal curve, when the duodenal tube is *in situ*, are pathognomonic evidence of duodenal ulcer. A normal or subnormal acidity, absence of blood in the duodenal contents and a distorted duodenal curve are pathognomonic evidence of periduodenal adhesions. The duodenal tube offers a much better means of differentiating duodenal ulcer and periduodenal adhesions, and also the diagnosis of these conditions, than the roentgen examination alone.

W. W. B.

Eggleston, E. L., Critical Review of 500 Cases of Gastric and Duodenal Ulcer. (*J. Am. M. Assn.*, December 4, 1920, lxxv,23.)

In this very able article the author shows a definite preference for medical rather than surgical treatment of gastric and duodenal ulcer. He states that if peptic ulcer, particularly the duodenal ulcer, is observed early and if the patient will submit to a carefully planned course of treatment for a reasonable time and will follow up this treatment by a carefully regulated diet for a period of some months, one can be sanguine of obtaining a complete cure. In addition, in uncomplicated cases of long standing, if put upon proper medical treatment the patient will be relieved in at

least 70 per cent of the cases. He further states that in a great majority of cases in which the symptoms disappear during medical treatment and return later, the fault is due to dietetic carelessness. He states that it is quite possible to have an ulcer only partially healed and that the relief of symptoms should not to be taken to mean permanent healing; that most of the cases, which are apparently cured by medical treatment but have in a lapse of some months the return of the symptoms, are due to the partial healing of the ulcer. His position in regard to surgical treatment is that it is to be preferred in cases complicated by pyloric stenosis not yielding readily to medical measures; also in cases showing repeated hemorrhages, penetrating or perforating ulcers; and for cases in which a prolonged medical course of treatment is impossible.

He lays particular stress upon the fact that gastro-enterostomy is by no means a curative procedure and should be resorted to only in cases of pyloric stenosis or in conjunction with resection of the ulcer, cauterization, infolding or gastrectomy. He also lays particular stress upon the fact that the patient after being discharged from medical care should observe the strictest regulations in diet for some month and that this should be impressed upon the patient, not only following medical treatment of ulcers but also following operative procedure.

W. W. B.

Roberts, D. The Roentgen Diagnosis of Gall-Bladder Lesions. (*J. Am. M. Assn.*, December 4, 1920, lxxv, 23.)

Roberts states that the roentgenographic diagnosis of gall-stones and a dilated gall-bladder is possible at the present time with a small percentage of failures. He mentions in technique that absolute stillness of the patient during exposure is essential. In the technique which he says gives the most satisfactory results he uses a medium focus gas or hydrogen tube, a target plate distance of 28 inches, a small cone giving an exposure field of 5 or 6 inches, a spark gap of 2½ or 3½ inches and 20 to 30 ma. He states that a negative diagnosis is of value dependent upon the intensity of detail and the sharpness of the image secured. He states that it is of very little value where satisfactory roentgenograms cannot be made, owing to the size of the patient. He claims that it is fallacy that only 10 or 15 per cent of gall-stones can be visualized and that the demonstration of the pathological gall-bladder is possible, because of the marked improvement in technique, especially in the use of duplitized films and double screens which makes the roentgen diagnosis easier. Roberts takes somewhat the same view as George of Boston, that all gall-bladder shadows which are shown are pathological, but he states that it has been his experience that the shadow of the normal gall-bladder is sometimes shown. Gall-bladder roentgenograms of satisfactory detail, as he states, can only be secured by using rays of low penetration with duplitized films and fast screens. He claims that the greatest limitation in roentgenographic diagnosis of gall-bladder disease is the impossibility at the present time of securing roentgenographic evidence of chronic gall-bladder inflammation, where there is no dilatation or a new growth of the gall-bladder or bile-ducts.

W. W. B.

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BENIGN AND MALIGNANT GASTRIC ULCERS FROM A ROENTGENOLOGIC VIEWPOINT*

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NOTWITHSTANDING the high efficiency of the roentgen ray in the diagnosis of gastric cancer and gastric ulcer, I have at various times pointed out that the roentgen-ray examination does not always determine the benignancy or malignancy of a given ulcerous lesion. As exceptions to this view have occasionally been expressed I believe that a broader discussion of the subject may contribute to still greater concord of opinion.

Roentgenologic distinction between typical cancer and typical ulcer is manifestly not difficult. One is a tumor mass intruding on the gastric lumen, the other is an excavation in the gastric wall. Correspondingly, the visualized gastric chamber shows a local diminution, a filling defect, in the former, and a local expansion, a niche, in the latter. One is plus, the other minus. These lesions are easily diagnosed; many are operated on and for the most part adequately proved.

From a pathologic standpoint this classification is rather diagrammatic. Between the classic tumor and the classic ulcer are innumerable gradations according to the predominance of one or the other feature. At operation are found ulcerating cancers, ulcers which contain a minority of cancer cells, and benign ulcers with or without surrounding tumefaction.

Roentgenologically we are obliged to group these lesions in two general diagnostic classes, the tumorous and the ulcerous. The tumorous lesions are commonly diagnosed by the roentgen ray as cancer, because experience has taught us that nearly all the gastric tumors are carcinomatous. The ulcerous lesions are reported by the roentgenologist as ulcers because the characteristic niche-deformity is within the wall of the stomach. When they are exposed at operation they generally have the macroscopic appearance of benign ulcer, but microscopic examination of tissue from the ulcer sometimes reveals cancer.

Ulcers which show microscopic evidence of cancer may be divided into two types. In one type both the border and the floor of the ulcer contain cancerous tissue in abundance, (Fig. 1.). These are generally believed to be ulcerating cancers which were malignant from the beginning. This was the opinion of Hauser who stated that in a primary cancer-ulcer the entire border and floor are constantly more or less infiltrated with cancerous tissue, inasmuch as the infiltration precedes the ulceration. In the second type the floor of the ulcer does not contain cancer but cancer is found in the ulcer margin. (Fig. 2). This type has been given special attention in connection with the development of can-

*Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D.C., Sept. 27-30, 1921.

cer on ulcer, a theme which has stimulated an extensive literature.

Many articles have been published by clinicians, surgeons, and pathologists representing every shade of opinion from that of Hirschfield, who denied any relation at all between gastric cancer and ulcer, to that of Zenker who held that most gastric cancers develop on ulcer. (See in bibliography, 1,4, 5, 7, 9, 10, 11, 12, 13, 14, 16, 17, 20, 21, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43.)

Except Hirschfield, who seems to be alone in his view, all agree that cancer may develop on ulcer, and only the frequency of such development is in controversy. Regardless of the issue of this debate, it is difficult to escape the conclusion that any ulcer is a potential cancer. The obvious corollary is that treatment should be surgical and the ulcer excised or destroyed.

Many malignant ulcers, particularly those containing small amounts of cancerous tissue, appear to be ulcers simply and solely, as seen by roentgenologists, clinicians, and surgeons. Abundant evidence can be gathered to substantiate this claim. Surgeons and pathologists see these lesions daily and have learned that they cannot depend on a gross examination to determine whether they are malignant or benign. W. J. Mayo says, "Even at operation it is sometimes difficult to determine whether the condition is cancer or ulcer . . . until a specimen is secured for microscopic examination." In a report of a number of such lesions, Wilensky and Thalheimer say, "In all these it was not possible to make the diagnosis of malignancy from the gross appearance of the specimens as they were observed at operation." Even in those adjudged to be benign microscopic diagnosis, they state, was arrived at with difficulty in a few because of atypical hyperplastic forms at the margin.

Ewing has made the statement, "In my own material I have had much difficulty in deciding how to interpret some ulcerating and cancerous lesions."

Küttner states, "In many cases it is not possible, either clinically or with the abdomen open, macroscopically to differentiate callous ulcer from cancer. The microscopic examination alone makes the differential diagnosis".

Payr, likewise, states, "Clinically, historically, and even after thorough macroscopic examination of the specimen a case may appear to be one of quite typical ulcer, and the subsequent histologic examination first tells us in an unequivocal way, the unpleasant fact that a beginning or advanced cancer is present".

Orth remarks that the macroscopically ulcerous appearance can never be relied on.

MacCallum has seen typical round ulcers, in the margins of which carcinomatous growth of epithelium of unmistakable character was found, although the tumor had not developed sufficiently to disturb the characteristic appearance of the ulcer.

Aschoff asserts that often only the microscope can determine whether or not a cancerous ulcer is present, and that the microscopic distinction is not always easy.

Henke believes that to determine macroscopically without sectioning whether a callous gastric ulcer is or is not cancerous is impossible in many cases.

From the roentgenologic standpoint Clairmont and Haudek write as follows: "Although many criteria make it possible to differentiate cancer from ulcer, this distinction is risky in a certain group of cases well diagnosed as chronic ulcer, whose transition into cancer cannot be excluded. . . . . Since at laparotomy the surgeon has difficulty in making the differential diagnosis macroscopically, since both diseases cause infiltrated glands, indeed since the histologic examination must be conducted most thoroughly in order not to overlook small groups of cancer cells, it can be understood that here roentgen diagnosis must find a limit". Again, they state, "The wide consensus of view that a chronic ulcer should have surgical treatment makes its differentiation from cancer superfluous. Certain it is that thereby many times the generation of a cancer will be prevented".

All this testimony is fairly representative of the mass of opinions and indicates the vanity of any hope we might have entertained that the roentgen examination may succeed in a task which is sometimes difficult for the microscope.

MacCarty has said, "If the surgical pathologist cannot always distinguish grossly simple, chronic, gastric ulcers from carcino-

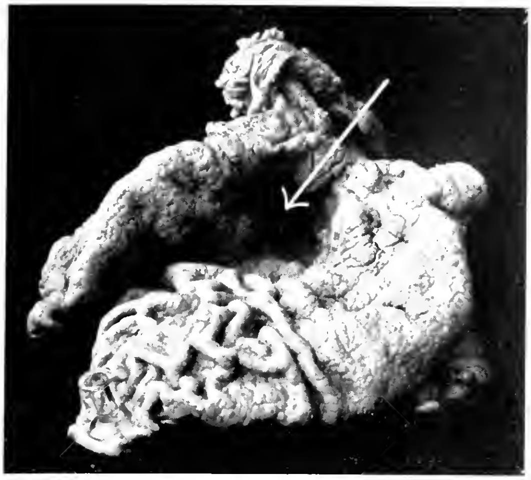


FIG. 1. CASE 206304. Malignant ulcer, niche-type. Cancer in floor and margin. Arrow indicates crater.

matous gastric ulcers, it is impossible for surgeons, roentgenologists and clinicians to make the differentiation with their lesser instruments of observation, there being no specific clinical or laboratory test for early cancer".

Conceding the justice of my colleague's criticism from the strict point of view of the pathologist, I believe, nevertheless, that to impose such limitations of diagnostic latitude would, under present conditions, impair the practical efficiency of the roentgen-ray examination. With the increased capability of the roentgen ray, clinicians and surgeons place correspondingly increased reliance on it, not only for the demonstration of gastric lesions but also for the determination of their probable character. That this reliance has not been entirely misplaced is, I believe, abundantly proved. On the other hand, I do not recommend or practice diagnosis on mere suspicion. All conclusions from the roentgen examination should be well reasoned, and the examiner should not be expected to give information which he cannot possibly obtain.

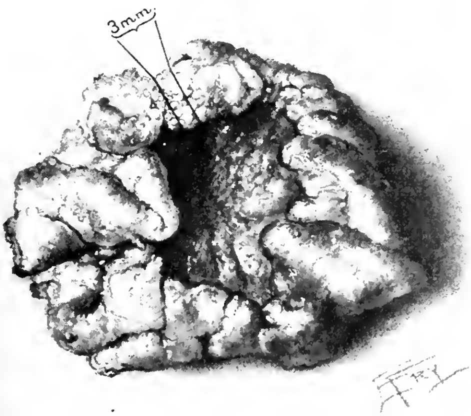
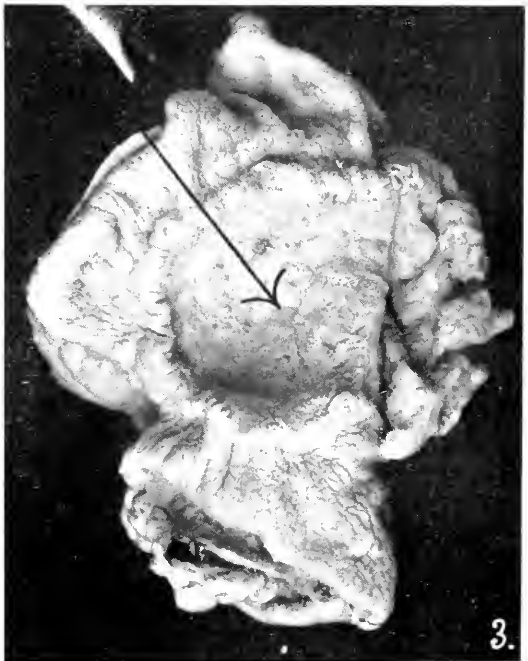


FIG. 2. CASE 346077. Malignant ulcer, niche-type. Cancer found over an extent of 3 mm. only, in margin.



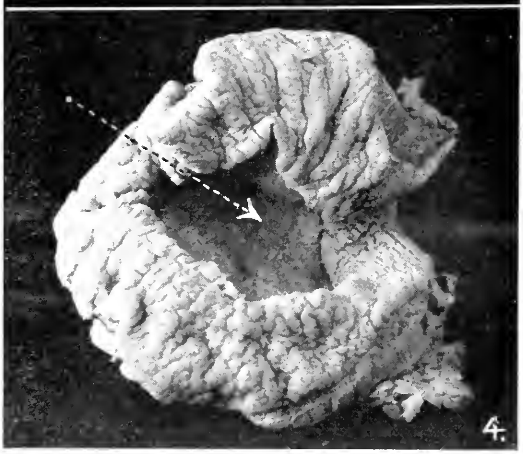


FIG. 3. CASE 262866. Ulcerating cancer. Large deep ulcer with overhanging margin. This is the type of ulcer whose crater may be seen as a meniscus during fluoroscopy.

FIG. 4. CASE 166828. Ulcerating cancer, having the same characteristics as the one shown in Figure 3.

Fig. 5. Drawing illustrating the demonstration of the lesion by palpation during roentgenoscopy.

It would seem that the roentgenologist is between two fires. On one side is the clinician who desires a maximum of diagnostic detail, and on the other is the pathologist who insists that the roentgen ray can furnish only a minimum of positive information.

At the roentgen laboratory of the Mayo Clinic we report the well defined ulcerous gastric lesion of the niche-type as "ulcer", be-

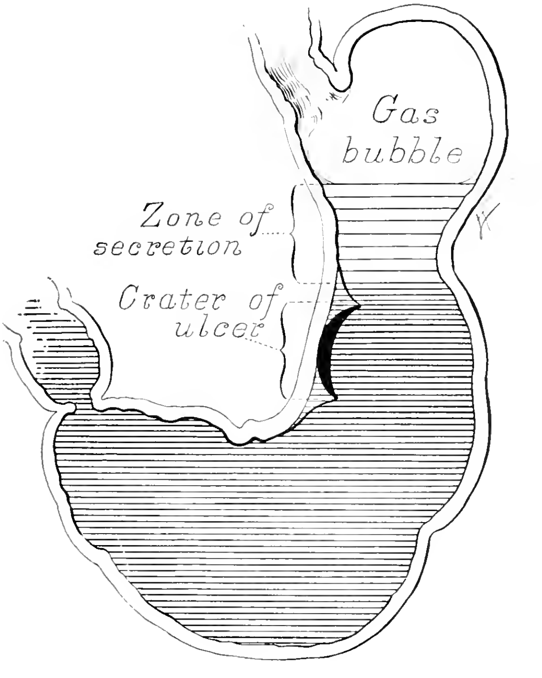


FIG. 6. Drawing illustrating meniscus-like appearance of crater seen in profile. Ulcer on the posterior wall near the lesser curvature.

cause in its gross characteristics it is an ulcer, and the examiner's associates understand very well that he cannot determine whether its histologic structure is benign or malignant. Likewise, a gastric filling defect with a palpable tumor is reported by us as "cancer", because experience has shown that 95 per cent of such tumors are cancers, and the empirical element in the diagnosis is thoroughly comprehended by all concerned. But when the clinician is not thoroughly acquainted with the roentgenologist's method of examination and his manner of expressing the results the latter should report his diagnosis in guarded terms. A lack of caution in this respect adds to the doubt of those who view roentgen diagnosis with skepticism.

As I suggested at the beginning of this paper some ulcerating cancers have the gross characteristics of both ulcer and cancer, (Figs. 3 and 4). When a cancer has undergone deep ulcerous excavation and the ulcer is surrounded by a wall-like overhanging margin it may present certain pathological peculiarities which I have recently described[6] and which I consider pathognomonic. Fluoroscopic examination is required to elicit these characteristics because palpatory manipulation is indispensable (Fig. 5). The picture thus obtained varies slightly with the site of the ulcer.

If the lesion is on the vertical portion of the lesser curvature or on the posterior wall near the lesser curvature, approximation of the walls of the stomach by palpation causes the crater of the ulcer to appear on the screen as a dark shadow resembling a meniscus as seen in profile (Fig. 6). The convexity of the meniscus is directed outward toward the gastric wall and its concavity toward the gastric lumen. When the ulcer saddles the lesser curvature of a fishhook stomach distal to the incisura angularis, the floor of the ulcer bends with the lesser curvature and its concavity is directed outward (Figs. 7 and 8). If the ulcer is high in the stomach on the posterior wall, well away from the curvature, thinning the barium by manual pressure reveals the crater as a somewhat rounded dense shadow encircled by a lighter zone, but no crescent is seen as when viewed edgewise (Fig. 9). By turning the patient into the lateral view and palpating the stomach the meniscus-like appearance of the crater may sometimes be obtained. It will be under-

FIG. 7. CASE 365132. Roentgenogram of ulcerating cancer saddling the lesser curvature, at the pyloric end of the stomach. Arrows point to meniscus. Irregularity of greater curvature due to spasm (Specimen, Figure 8).

FIG. 8. Same case as in Figure 7. Ulcer sectioned through the lesser curvature showing half of the crater. Note the thick indurated base and overhanging margin.

stood readily that other modifications of this sign may result from variations of the pathologic condition or situation of the lesion. For example, the floor of the ulcer may be flat instead of curved and show in profile as a straight line. The manner of palpation and degree of pressure exercised also affect the outline of the visualized crater, so that it may appear rectangular or biconcave, or otherwise.

Briefly summarized, the visualized crater of this ulcer differs from the classic niche-type in three particulars: (1) the crater is not within the wall of the stomach and therefore does not project from the visualized gastric lumen; (2) in profile the crater appears as a meniscus; and (3) it tends to retain its barium content during palpatory maneuvers and is not easily emptied (Fig. 10).

For two or three years I have been observing ulcerous lesions with the foregoing characteristics. Operative and pathologic findings, both gross and microscopic, have consistently verified the diagnosis of cancer.

On the other hand the niche-type of ulcer (Figs. 11 and 12) produces virtually the same roentgenologic manifestations whether it is benign or malignant, and any prediction of its probable character based on the roentgen-ray findings is hazardous (Figs. 13 and 14).

Large size of the ulcer crater is one indication of malignancy. When the niche representing the crater is 2.5 cm. or more in diameter, cancer is usually found in the ulcer on microscopic examination (Fig. 15). Unfortunately a smaller ulcer may also be carcinomatous, or a larger one may exceptionally be benign.

In this connection it should be mentioned that a perforated ulcer producing an accessory pocket, no matter how large, is seldom malignant. It is true that an ulcerating cancer may break through the gastric wall and attach itself to adjacent tissue, but filling defects suggesting the presence of a tumor are also likely to be seen.

A marked filling defect or gross deformity of the gastric outline adjacent to a niche may suggest malignancy. Such deformities, however, are most often due to induration, perforation, adhesions, or spasm accompanying a benign ulcer.

Other minor manifestations of benign and malignant niche ulcers offer little or no

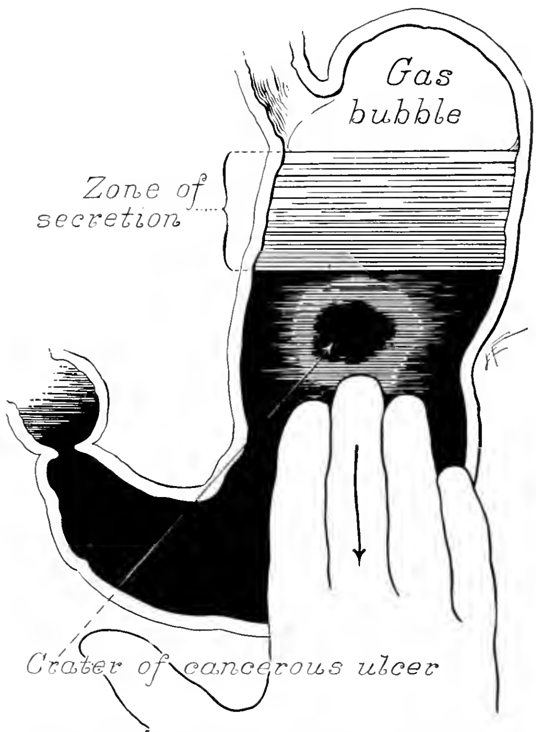


FIG. 9. Drawing. Ulcerating Cancer of the posterior wall. Appearance of the crater at roentgenoscopy on palpation.

FIG. 10. CASE 371607. Roentgenogram negative. Ulcerating cancer on the posterior wall of the middle portion of the stomach, near the lesser curvature Meniscus-like crater seen at roentgenoscopic examination.

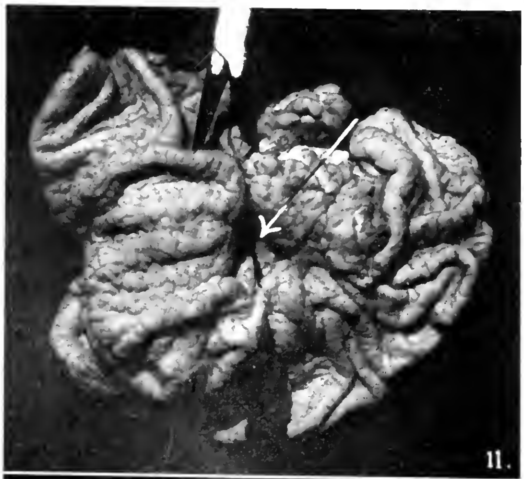


FIG. 11. CASE 346953. Benign ulcer. Arrow points to crater. Note similarity to Figure 12.

FIG. 12. CASE 202220. Malignant ulcer. Arrow indicates crater. Compare with Figure 11.

aid in the effort to distinguish between them. Cancers which are not mechanically obstructive are commonly associated with achylia and a gaping pylorus, while benign ulcers, even though distant from the pylorus, are likely to be accompanied by hyperacidity, spasticity of the pylorus, and six-hour retention. But such findings are not constant in either variety of ulcer, and only slight weight can be attached to them.

The broad incisura of cancer and the narrow incisura of ulcer, both of which are contractures of the greater curvature in the plane of the lesion, depend on the extent rather than on the character of the lesion. Thus, while a broad incisura would correspond to an extensive lesion which because of its size is open to the suspicion of malignancy, the small ulcer with a narrow incisura is not wholly exempt from mistrust.

Alterations of peristalsis are of trifling differential significance. A gross malignant ulcer is more often associated with anacidity and peristaltic sluggishness, a simple ulcer with hyperacidity and peristaltic vigor, but the reverse may occur, and it would be folly for the examiner to be influenced by the peristalsis observed.

SUMMARY

There are but two varieties of ulcerous lesions which evince any noteworthy roentgenologic indications of malignancy. One is the ulcerating cancer with the meniscus-like crater. The other is the niche-type of ulcer with an unusually large crater. With these exceptions the examiner cannot venture opinions as to the probable character of ulcers revealed by the roentgen ray, nor should he be expected to do so. Any ulcer which appears to be benign macroscopically may prove to be malignant microscopically. Cancer may arise in an ulcer which was primarily benign.

However interesting and important these facts may be to roentgenologists, clinicians, surgeons, and pathologists, they are vastly more important to the patient, whose welfare should be our first consideration.

FIG. 13. CASE 154564. Roentgenogram. Niche-type of ulcer, benign. Arrow points to niche. Compare with Figure 14.

FIG. 15. CASE 20799. Roentgenogram. Niche-type of ulcer. Niche extraordinarily large. Operation. Cancer demonstrated microscopically.

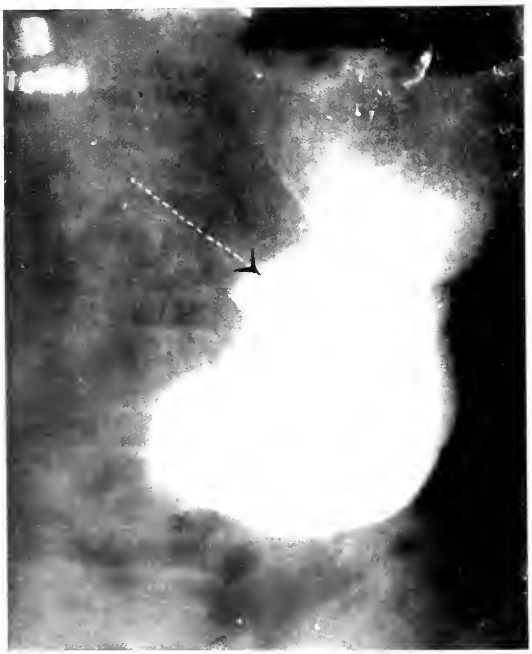


FIG. 14. CASE 116521. Roentgenogram. Niche-type of ulcer, malignant. Arrow points to niche.

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DISCUSSION

DR. G. W. HOLMES. I hesitate to discuss a subject which has been presented by a man who has had such an extensive experience as Dr. Carman. But in our clinic at the Massachusetts General Hospital, we have a group of pathologists who practically never make a diagnosis of cancer on ulcer. The findings on which we base a differential diagnosis between cancer and ulcer are quite different from Dr. Carman's. We put considerable stress on the peristaltic function of the stomach.

Assuming that cancer is a primary lesion, then the duration of illness is so short that the muscular structure of the stomach does not have time to hypertrophy, and we do not get the extreme hypermotility that we see in chronic ulcer. In our clinic, we are examining about 2,000 cases a year. We have not analyzed them so carefully as Dr. Carman has.

In 1914, we reported the results of our cases, and in 1920, we tabulated them again. Our findings ran much the same in 1920, as they did in 1914. We found a considerably larger number of cancers than ulcers. I think it would be fair to assume one of two things. Either we must be missing a considerable number of ulcers, or cancer is more frequent than ulcer in our clinic. Supposing that most cancers arise on ulcers, then we ought to find more ulcers than cancers, but we do not find this to be true. If we were missing them, the surgeon would check us up. In all cases,we have a brief history taken. It is not like the one which the gastroenterologist would make—perhaps, it is a little better in some ways, because we do not suggest anything. Take a large number of these cases and note the duration of time elapsing from the first symptoms until the lesion is found. Most cancer cases will come within a

period of months, whereas ulcer cases come within a period of years.

I think that the differences in our observations and those of Dr. Carman are not due to technique, as we use practically the same, but rather to the difference in the opinion held by the pathologist with whom we work.

Dr. Franklin W. White. One thing which appealed to me in the remarks of Dr. Carman was the fact that fluoroscopy and careful palpation were necessary to discover some of these cancers. I was struck with the large size of some of the cancers which he showed in his diagrams which did not show on the plates. Sometimes roentgen examinations of the stomach are carried through without fluoroscopic examination—I think, however, that this is done less and less, and I am sure that we have been shown that even such a large, serious, and important lesion as a well developed cancer on the posterior wall of the stomach may be entirely missed without the use of the fluoroscope. Nothing is more serious or embarrassing, and nothing brings more discredit on the roentgen examination than to entirely miss a good sized gastric cancer. I feel sure that this method of fluoroscopy and palpation which Dr. Carman has described will prove very valuable in this field. With regard to the frequency with which cancer may develop upon ulcer, that question, is still under a great deal of discussion. As a clinician it seems to me that it occurs much less frequently than we should expect from the statistics which have come from the Mayo Clinic.

Dr. Carman (closing the discussion). A number of things were brought up in the discussion which are irrelevant to the paper. Exact proof of the development of cancer on ulcer is difficult to obtain. No one has ever seen the process of transformation in actual progress. Yet most pathologists agree that it does occur, and disagree only as to the frequency of its occurrence. Some have estimated that 80 per cent of cancers have developed from ulcers. Personally, I do not believe that the percentage is as high as was originally thought.

The cases that give the meniscus sign are few in number. We have seen only twenty-five or thirty in the last three or four years. Cancer is an ulcerating disease, but many ulcerating cancers do not give this sign. Only those with deep craters and overhanging margins can be seen in this form. All that we have met with have been malignant. As was shown in the slides palpation is absolutely essential to demonstrate this lesion when it is above the incisura angularis. I am quite sure that early in our work we have missed diagnosing many of these cases.

ROENTGENOLOGICAL STUDIES OF INJECTED KIDNEYS*

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THERE is no other system in the human body which presents such peculiarities of development as the urogenital system. The nephridial system is even more complicated than the reproductive. This is due to its three stages of development which eventually merge into one, the metanephric stage. When the pronephric stage is succeeded by the mesonephric and the mesonephric in turn by the metanephric is still a matter of conjecture.

The developmental peculiarities of the nephridial unit alone are sufficient to make the study of the subject interesting as well as instructive. They afford an inexhaustible field for further investigation and research.

In the preparation of this paper, the writer is fully conscious of the depth and magnitude of the subject. He therefore at this time simply wishes to present a preliminary report of his work on injected kidneys, viewing the question particularly from the standpoint of pyelography. He hopes in the course of the discussion, to be able to give a few new facts additional to those which have already been written upon and discussed by other writers.

In the daily routine of *x*-ray work on kidneys one is often puzzled in his attempt to give a true interpretation of shadows cast

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by the renal pelves and calyces; in other words, to determine where the normal ends and the pathological begins. This desire to know as much of the truth as possible regarding the actual shadows of kidneys upon the sensitized *x*-ray plates, unobstructed by the intervening tissues and unaltered by pressure caused by neighboring organs or by distended blood-vessels, has led the writer to go further into the study.

The specimens used in this work include:

1. Freshly removed kidneys of adults, children, and feti from autopsy and surgical cases.

2. Freshly removed kidneys of animals, which as far as can be ascertained are normal.

3. Kidneys injected in situ soon after death.

4. Pathological kidneys injected before and after surgical intervention. Follow-up cases.

Before going further into the discussion, it is well that we freshen our minds with a short review of the gross anatomical structures and landmarks of the renal ducts. Regarding the urogenital system from the standpoint of its embryological development, the nephridial unit consists of:

1. The ureter.

2. The pelvis proper and its branches, the calyces.

An adult ureter is a pale-colored, thick-walled duct with a small lumen. It measures while in situ about 25 cm. in length, extending from the pelvis to the urinary bladder. It has normally three narrowings:

1. At a distance from 4 to 9 cm. below the hilus of the kidney.

2. Near the brim of the bony pelvis.

3. At the lower end of the ureter as the duct penetrates the wall of the bladder.

The pelvis, as a rule, is irregularly pyramidal in shape, tapering gradually until it reaches the ureteropelvic junction, at the region of the first narrowing. It is placed partly within and partly outside the sinus. Opinions differ as to the number of the main divisions of the pelvis of the kidney. Piersol says: "These include the divisions of the pelvis into an upper and a lower segment (calyces majores), extending towards the respective poles of the kidney." Cunningham puts it in this manner: "It is formed by the junction of two, or more, rarely three, thin-walled tubes, the calyces majores, each of which has a number of branches." Braasch, on the other hand, in describing the major calyces of the kidney, says: "The major calyces are commonly three in number, the upper, the middle, and the lower." For descriptive and practical purposes, and especially from the standpoint of pyelography, the writer prefers to look upon the renal pelvis as having three divisions like those seen in the primitive type of renal pelvis. He, therefore, will make use of Braasch's description as a working basis in the course of the discussion of the paper.

The pelvis, then, let us say, divides into three main divisions called the superior, middle and inferior major calyces, each occupying the upper pole, the middle portion, and the lower pole of the kidney respectively. Each of the major calyces, after springing from the pelvis proper in the form of a stem, subdivides into from four to six smaller branches known as the minor calyces. The terminal ends or apices of the minor calyces open up like so many buds in a rather broad cup-like depression. The latter form receptacles into which the renal papillae empty.

The foregoing brief description gives us a fair view of the structure of the renal ducts as generally conceived. But in actuality and in daily *x*-ray work, one unfortunately does not find them to be always so. They are subject to extreme variations and anomalies.

From the study of the various roentgenograms of normal renal pelves and blood-vessels, the writer is prepared so far in his investigation to give the following findings:

First, that work upon normal kidneys of adults, infants, and feti reveals that there is always a constant dissimilarily in capacity, size and shape of the pelves and the number of calyces, not only between two different persons, but also between the two kidneys removed from the same subject.

Second, that the superimposition of the shadow of one or more calyces upon the other portion of the calyces and pelvis will throw a shadow which often resemble a stone in the pelvis. Again, if the cup-like terminal depression of the minor calyx happens to be a very deep one, it will produce a ring-like shadow of less density than the main shadow, and this may be mistaken for a

Fig. 1.

Fig. 2.

Fig. 1. Case 1. Pyelogram of normal human kidney. Three major calyces are present. The middle major calyx is very small. There is a complete absence of the minor calyces, the major calyces terminating directly in terminal depressions.

Fig. 2. Case 1. Pyelogram of normal human kidney, showing the relation of the renal arteries to the pelvis and calyces in this particular specimen. The veins were not injected. Note the partial obliteration and constriction of the superior and inferior major calyces, caused by the crossing of the arteries.

renal calculus. Very frequently also the main renal vessels cross the upper portion of the pelvis, the isthmus of the major calyx and the minor calyx. The crossing of these vessels, especially if they are in a state of distention, will bring about a distorted and an abnormal shadow, isolating either the minor and major calyx from the main body of the pelvis or producing a partial obliteration or constriction of the isthmus. This condition will again make the interpretation of the pelvis shadow erroneous.

Third, everything being equal, the ureteropelvic junction of the four kidneys of infants, aged nine and twelve respectively, show a constant tortuosity. The tortuosity can be better demonstrated on the stereoscopic screens. It is not due to faulty technique nor to post-mortem contracture, for they were removed and prepared in exactly the same manner as the other kidneys of infants and feti. The writer does not wish to comment or advance any theory regarding this unusual finding, for it is too premature, and further, the materials worked upon so far are not sufficient in number to warrant one to draw any conclusion. Further study will be made upon this particular question. Pedicles of a twelve-day old baby, and of five and six months old feti do not give this picture.

Fourth, in the two extremes of age, the calyces are easily ruptured. In the very young this is due to the friability and thinness of the walls of the pelvis and the calyces, whereas in old people it is due to the brittleness and unyielding condition of the walls. This teaches one a good point in pyelography, in that pressure used in one's attempt to introduce opaque medium into the pelvis is beset with dangers. Gravity method is the safest, although it may take considerable more time in the procedure. The writer hopes to be able to demonstrate satisfactorily the above points on the lantern slides.

Taking the time element into considera-

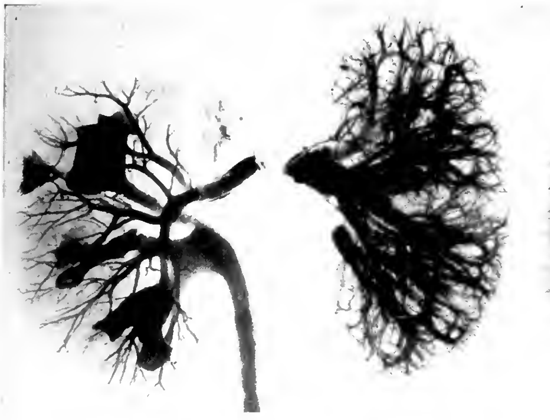

FIG. 3.

FIG. 4.

FIG. 3. CASE X. A. Pair of kidneys from the same subject. The right one shows simply the blood-vessels. The ureter and pelvis were not injected. The left one shows a pyelogram of the kidney with the main arteries injected, demonstrating their relation with the structures of the pelvis.

FIG. 4. CASE X. B. The same as Case X A. Note particularly the pyelogram of the right kidney. There is an attempt on the part of the ureter toward duplication. Complete absence of the pelvis.

tion, the writer is obliged to describe at most only two cases from each set of kidneys. There are four sets in all, covering an investigation work on fifty-five kidney specimens. The first set consists of normal adult kidneys; the second, of normal fetus and infant kidneys; the third, of animal kidneys, and the fourth of pathological human kidneys.

CASE I. (Figs. 1 and 2). Male, aged thirty-five. Cause of death: Epithelioma of the lung, secondary metastasis of the esophagus.

Specimens: Left Kidney. The first injection is to show the outline of the kidney pelvis and calyces. The second injection shows the relation of the renal artery to the pelvis and calyces. This is a normal pelvis. Number of major calyces, three. The superior major calyx terminates into just one broad papillary depression without having a minor calyx. The middle major calyx springs directly from the pelvis proper, terminating in a small papillary depression. The inferior major calyx is broad, terminating in four papillary depressions, deep and hollow. One of the depressions superimposes the isthmus of the calyx, simulating the shadow of a calculus. The minor calyces in this case are wanting, the apices of the major calyces ending abruptly in papillary depressions. The distended arteries of the upper pole cross and hug closely the isthmus of the upper major calyx and also that of the middle major calyx, producing a partial obliteration and isolating the terminal portions of the calyces from the pelvis proper.

CASE II. Female, aged twenty-three. Cause of death: Attempt made on part of patient to induce self-abortion, by taking some proprietory preparation of ergot. Autopsy revealed that there was no product of conception present. There was however a polyp hanging from the fundal portion of the uterus.

CASE III. Female, aged twenty-five. Cause of death: Suspected drug addict, having taken an overdose of habit-forming drug.

CASE IV. Male, aged twenty-seven. Cause of death: Very malignant sarcoma. Death very rapid.

CASE VI. Male, aged forty. Cause of death: Accidentally buried in a sewer which caved in while he was working in it.

CASE VII. Female, aged twenty-six. Cause of death: double pneumonia.

CASE VIII. Female, aged thirty. Patient is living and well at present. Diagnosis: Pyonephrosis. Pelvic Kidney.

CASE IX. Female, aged sixty. Cause of death: Generalized carcinoma.

CASE X. (Figs. 3 and 4). Male, aged thirty. Cause of death: Asphyxiation.

Specimens: Two Kidneys. In the first in-

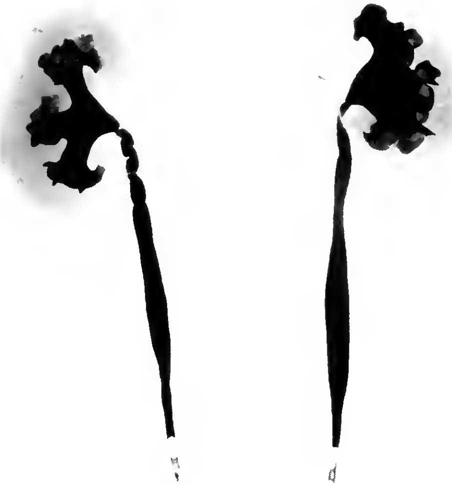

Fig. 5.

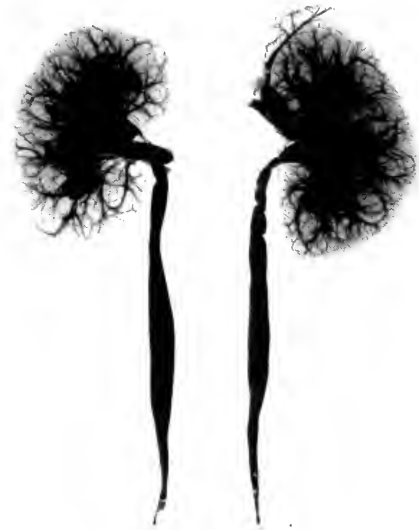

Fig. 6.

Fig. 5. Case XIV. Pyelo-ureterograms of a pair of infant kidneys. Aged nine months. This case is to demonstrate the tortuosity of the pedicles of both kidneys. The blood-vessels were not injected. The pelvis proper is relatively large and the minor calyces bud out almost directly from the pelvis proper. Stereoscopically seen, the three major calyces have eight minor calyces. This is a typical type of renal pelvis in its early developmental stage.

Fig. 6. Case XIV. Pyelo-ureterograms of a pair of infant kidneys. Aged nine months. This case is to demonstrate the relation of the blood-vessels to the pelvis and calyces. Note the dissimilarity in the shape of the two pelves.

Fig. 7.

Fig. 8.

Fig. 7. Case XV. Pyelo-ureterograms of a pair of infant kidneys. Aged twelve months. This case, like Case XIV, is to demonstrate the tortuosity of the pedicles of both kidneys. The blood-vessels were not injected. The right kidney shows three distinct major calyces, whereas the left kidney shows a diminutive form, budding out as part of the inferior major calyx. Note the difference in shape between the two pelves.

Fig. 8. Case XV. Pyelo-ureterograms of a pair of infant kidneys. Aged twelve months. This case, like Case XIV, is to demonstrate the tortuosity of the pedicles of both kidneys. Both the arteries and veins were injected, so as to show their relation to the pelves and calyces.

jection the right kidney pelvis and ureter were not injected, only the arteries and veins. In the left kidney the ureter, pelvis and the arteries only were injected, whereas the veins were left untouched. In the second injection the pelvis and ureter of the right kidney were injected. It is interesting to note in the case of the right kidney that there is a complete absence of the pelvis; the superior and inferior major calyces spring directly from the pelvis, the superior major terminating in a broad apex with two terminal depressions, and the inferior major in two minor calyces. The left kidney has a relatively small pelvis. Three major calyces are present. The superior springs directly from the upper margin of the pelvis in the form of a long narrow isthmus with broad apex. The latter has two papillary depressions. The middle also springs directly from the pelvis in a long narow isthmus with two minor calyces at its terminal portion. The inferior is short and divides at its terminal portion into three minor calyces, each having one papillary depression. The ureter is abnormally large. There is an attempt toward duplication on the part of the ureter.

CASE XI. Male fetus, aged five months. Miscarriage.

CASE XII. Male fetus, aged six months. Miscarriage. Kidneys were injected in situ.

CASE XIII. Male infant, aged twelve days. Malnutrition.

CASE XIV. (Figs. 5 and 6). Male infant, aged nine months. Pyloric stenosis. Especially interesting in that the pedicles of both kidneys show tortuosity. The shape of the right pelvis is a type seen in early pelvis. All the calyces spring directly from the pelvis. In the first injection only the ureters and pelves were injected. In the second injection both the arteries and veins were injected.

CASE XV. (Figs. 7 and 8). Male infant, aged twelve months. Malnutrition. The same condition of the pedicles of both ureters exists as in Case XIV, only that the tortuosity is more marked.

CASE XVI. (Fig. 9). Kidney of beef. The architecture of this kidney much resembles that of the fetus of five months, with but one exception. The upper and lower poles of the pelvis throughout their entire length branch out into secondary divisions, and each of the secondary divisions in turn subdivides into two, three and four minor calyces. The papillary indentations with their stems look very much like so many lilies of the valley, especially if they are viewed from the negatives stereoscopically, each having a deep, rounded, hollow depression.

CASE XVII. Kidneys of lamb. They are not lobulated as the beef kidney. The pelvis is somewhat crescentic in shape. It has seven pairs of leaf-like projections in each half of the kidney proper. And each projection has a counterpart on the opposite side and is symmetrically arranged. Kidneys of dogs and raccoons bear the same fundamental structural formation as those of lambs. The only difference is in the number of the leaf-like projections. They are not so complex and subject to variations as those of the human kidneys.

CASE XVIII. Kidneys of dog.

CASE XIX. Kidney of raccoon.

CASE XX. Kidney of pig.

CASE XXI. (Fig. 10). Male: aged fifty-two. Hospital case No. 571. Clinic case No. 5452.

Specimen: Right Kidney. Gross Description. The specimen is a small kidney. The capsule does not strip easily. The entire kidney structure shows an increase of connective tissue. At one pole the cortex is decreased in thickness to ¾ mm. over a cavity and the inner surface at this point shows an old healed fibrous scar 4 mm. in diameter. The pelvis contains an excess of fat.

Microscopical Description. One section exhibits both cortex and medulla. In the cortex the convoluted tubules show albuminous degeneration. The medulla shows an increase in interstitial connective tissue..

In another section at one point, the capsule is thickened and degenerated. Beneath the scarred area there is a focus of parenchymal destruction with scarring of large numbers of glomeruli and diffuse round-cell infiltration and necrosis. Here there are seen a few old tubercles. In places there is marked hyaline degeneration of the interstitial tissue. The epithelium of the calyces is eroded. There is a zone of small round-cell infiltration and necrosis.

Diagnosis. Chronic pyelonephrosis; old focal tubercular infection; chronic interstitial nephritis.

No pyelography of the case was taken be-

Fig. 9. Case XIX. Beef kidney. This is to demonstrate the manner in which the major calyces branch out into secondary divisions. Each of the latter again subdivides into two, three and four minor calyces. The terminal depressions are large, deep and hollow, resembling lilies of the valley.

fore its removal. This is due to the presence of a renal calculus in the lower third of the right ureter.

The first picture of the case shows the stone in the right ureter. The second is a photograph of the kidney before injection. The third is a diagrammatic drawing of the kidney lamina as indicated by the two probes The fourth is a drawing of the kidney after it has been sectioned, with the probe used to indicate the passage between the upper and lower pelves. The fourth is an injected picture of the pelvis, showing that there is no connection between the blood supply of the lower and the upper or supernumerary kidney. The shape of the pelvis is like a curve tube. The blood vessels seen in the smaller pelvis are those which appear superficially. They were injected because the writer thought that they belonged to the mass.

Case XXII. Male, aged twenty-one. Hospital case No. 1541. Clinic case No. 7219.

Specimen: *Right kidney*. Weight 1 lb.; length 14 cm; width 8 cm.; number of renal calculi 27.

Diagnosis. Nephrolithiasis with pyogenic infection; hydronephrosis.

No pyelography was made of the case on account of one of the renal calculi completely obstructing the passage between the pelvis proper and the ureter. The first picture is a drawing of the specimen before injection and cutting it open. The second picture is a drawing with the specimen cut open, showing the renal stone lodged in the different cavities. The third picture is an x-ray picture of the specimen soon after its removal before injection was done. The fourth picture shows an injected kidney.

Case XXIII. Female, aged thirty-two. Hospital case No. 5401. Clinic case No. 1501.

Specimen: *Right Kidney*. *Diagnosis*. Chronic tubercular infection of the right kidney with marked destruction.

Case XXIV. (Figs. 11 and 12). Girl, aged six. *Specimen: Right Kidney*. Weight 1 lb. 15.5 ounces.

Roentgenological Description of the Pel-

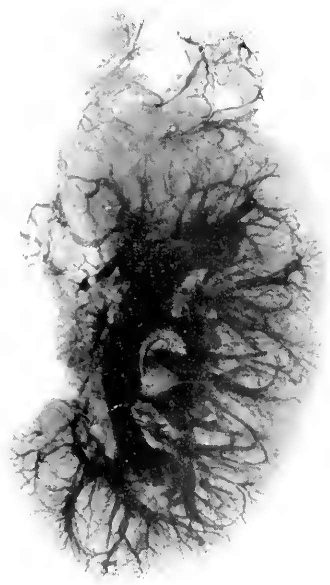

Fig. 10. Case XXI. Left kidney. Supernumerary kidney. Chronic pyelonephrosis with old focal tubercular infection, and chronic interstitial nephritis. The pelvis and the blood-vessels were injected. Note the shape of the pelvis and the condition of the blood-vessels.

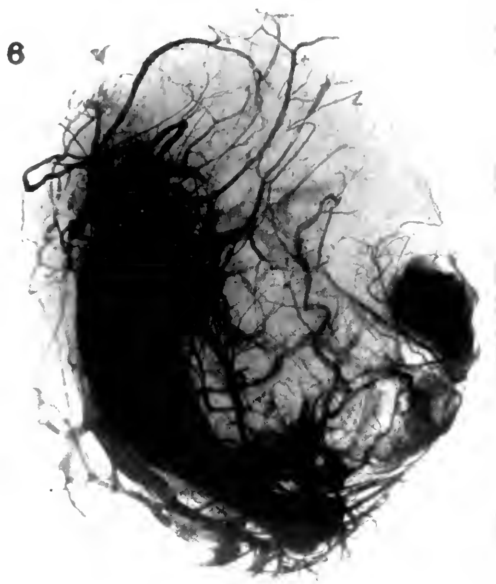

Fig. 11.

Fig. 12.

Fig. 11. Case XXIV. Pyelogram of hypernophroma. Note the seal-like appearance of the pelvis and calyces.

Fig. 12. Pyelogram of hypernephroma, the same as Fig. 11, only that in this case the blood-vessels were injected in order to demonstrate the blood supply of the tumor.

ves of the Tumor. The contour of the pelvis with its calyces resembles very much the figure of a sea lion. It is long and somewhat cylindrical. Its outline is perfectly smooth and clearly defined at all points. There is not a suggestion of haziness present. The superior major calyx, which looks like the cephalic portion of the sea lion, has only two stalky, club-shaped minor calyces. The inferior major calyx, which in turn resembles the caudal end, has also two minor calyces with broad stems and truncated apices. Its terminal portion is fan-shaped, and merges directly with the pelvis proper. The ureter, which is abnormally very small, projects abruptly from the center of the pelvis, producing a sort of valvular effect for the outflow of the pelvic contents. The blood-vessels supplying the tumor have the following peculiarities. First, they do not follow a definite coure or direction. Second, they are extremely long and tortuous. They are atypical in their arrangement. Third, they do not give the appearance of end arteries as seen in normal kidneys.

The tumor mass is not so scantily supplied with blood-vessels as is often understood. With the exception of a very small area, about 1.5 cm. in length, situated at the lower pole of the kidney, there is no normal renal tissue left. In this particular spot the course of the blood-vessels is normal, ending in end arteries.

TECHNIQUE

In order to obtain a true and undistorted shadow of the ureter, the pelvis and its calyces and the blood-vessels, it is quite necessary that the specimen should be fresh. Soon after its removal from the subject at autopsy or patient at the operating room, it is immersed in warm saline. This procedure will prevent further coagulation of the blood which is in the larger blood-vessels and capillaries.

If clotting has already taken place, injection of the vessels with saline solution becomes essential. When they are well distended and the hypodermic needle is still at the cut end, a gentle massage is applied over the specimen. This done, it is again replaced in the warm saline solution and the needle removed.

After all the blood has been removed

from the vessel, the fatty tissue of the hilus and surrounding the kidney is next removed. Here care must be exercised so that no vessels are torn and the kidney tissue injured, for the slightest injury to the parenchyma will make injection of the vessels futile.

The object in removing the superfluous fatty tissue is twofold: first, to clear the field of operation; second, to prevent the medium which may happen to escape the syringe from adhering upon them. If this is permitted to take place, when the specimen is radiographed, confusing shadow on the x-ray negative will result.

Before injecting the pelvis through a part of or the entire ureter, remove all the free fluid from it first. Should there be any retained fluid unremoved, it will modify the proper density of the injected medium.

In obtaining a specimen for this purpose wherever it is possible and perfectly safe, as from a subject at autopsy, the following points should be observed: first, that no injury is done to any part of the kidney perenchyma, that is the tissue continuity of the surface of the organ should remain intact. This is especially important when one wishes to inject the arteries and veins. Second, remove as much of the ureter with the kidney as possible, as this will facilitate injecting the pelvis considerably. Very frequently, in the course of injecting the ureter, air is introduced accidentally into it and air bubbles will result. A long ureter will obviate this difficulty, as the bubbles can be forced back into the ureter near the cut end. Third, ligate the larger blood-vessels as far away from the renal sinus as possible. Do not apply any traction upon them, as this will traumatize the smaller vessels in the sinus and the substance of the kidney.

In injecting a kidney in a living person a 17.5 per cent solution of sodium iodide is used. A regular cystoscopic method of procedure is employed. A detailed description of the technique is not necessary in this paper.

In injecting an extirpated kidney a plain barium sulphate suspension is used. Barium water solution seems to give the best result in this kind of work so far. It may have its drawbacks, but they are overbalanced by the results it gives upon a sensitized x-ray plate. Its disadvantages are:

1. If the solution is too thick, it will not only not penetrate into the finest capillary network, but it will also clog the hypodermic needle used to inject the finer blood-vessels.

2. If, on the other hand, the suspension is too thin it will not give a clear-cut shadow of the structure injected.

3. The mixture does not remain long in a state of suspension, that is, the barium settles down to the bottom of the container very readily.

To remove the first and second objections, one of the most practical means of telling whether or not the medium is sufficiently thick, is to add to the water gradually the barium sulphate, stirring it at the same time until it reaches a thickness that will pass through the lumen of a small hypodermic needle, gauge 23. Another way of preparing it is to add to every 12 ounces of barium sulphate 30 ounces of water without the admixture of acacia.

To force or inject the medium, hypodermic needles of different sizes are used, each depending upon the size and lumen of the blood-vessel and ureter.

The points of the needles are first clipped off and filed to a desired bluntness. The needle is first introduced into the lumen of the vessel or ureter, a piece of thread is tied round it, and then a luer syringe containing the medium is attached to the needle. This having been done a very slow and careful digital pressure is applied to the piston of the syringe. The pressure is immediately released the moment there is a slight resistance offered by the vessels injected. The cut end of the vessel is then tied and the needle removed. The specimen is now ready to be roentgenographed.

The writer will not go into detail as to the technique in roentgenographing the specimen, as space will not permit. The essential points only will be mentioned here. The specimen is now placed over an aluminum tunnel, and a fine focus Coolidge tube is set for a stereoscopic exposure. Very often, however, just before exposure, it becomes necessary to inject more of the medium, as some of the water will have been absorbed and the pelvis or the blood-vessel will collapse. If this has to be done, insert the needle immediately at the point nearest the tied

end into the lumen, and when the desired distention is obtained, draw the needle very carefully and apply another tie in front of the point of the needle.

Exposure technique is as follows: Fine focus Coolidge tube, current of a 5 ma., 1.5 or 2-inch spark gap, 20-inch target-plate distance, inductance 1, and 35 seconds' exposure.

CONCLUSIONS

1. A study of a series of injected normal kidney pelves enables one to get a general conception of what really constitutes normal shadow on the sensitized *x*-ray plate. He becomes prepared to meet the vagaries in the development of kidney pelvis.

2. The capacity, size and contour of the different renal pelves fundamentally may be similar, but comparatively they are dissimilar. No two pelves, not even those removed from the same subject, bear a similarity one to the other.

3. Superimposition of the minor calyces upon the isthmus throws a shadow which very often simulates renal calculi.

4. Distended renal blood-vessels, especially the arteries, which happen to cross the pelvis, the isthmus and the calyx, affect the contour of these structures, giving them a distorted and abnormal shadow.

5. In four kidneys removed from two subjects, aged eight and twelve respectively, there is present a constant tortuosity at the ureteropelvic junction.

6. The number of minor calyces springing from one major calyx ranges from one, and even a complete absence of, to seven and eight. The inferior major calyx as a rule has a greater number of minor calyces than the superior.

7. The middle major calyx, generally, is very small, springing from the pelvis either in a diminutive form or branching out as a part of the inferior major calyx.

8. The pelves of lower animals show a more primitive stage of development. They are simpler and more symmetrical in their formation.

Note. The writer wishes to express his great indebtedness to Dr. Alexander W. Blain and Dr. Ira G. Downer for their staunch support from the beginning of the investigation work. To Dr. Paul Eisen and Dr. Leo E. Grajewski he owes much for their invaluable suggestion. His thanks are also due Dr. James E. Davis, Professor of Pathology of the Detroit College of Medicine and Surgery for the careful pathological studies. The drawings are the work of J. H. D. Ferguson, artist of the Department of Medical Research of the Jefferson Clinic.

DISCUSSION

Dr. Lim. In regard to Dr. LeWald's question on technique of injection, not wishing to go into detail, I will say that we use simply plain barium water, that is, plain water and barium sulphate. No acacia is used. We have tried acacia with barium water, but it proved a failure, because it was too thick. We use only digital pressure, and the pressure is released as soon as there is a certain degree of resistance offered. No mechanical pressure at all is used. A little practice will give one the desired results. Hypodermic needles of the finest caliber are used for the smaller arteries and stub-pointed needles for the larger vessels and ureter.

We find so far in the work that barium water serves the purpose very well indeed. However, we will not stop here, but will go further in the use of other media. It has been suggested that possibly red lead might do, but we have not as yet tried it. Reasons again for using plain barium suspension are that the pathological specimen is not destroyed by this medium, for it can easily be washed off after the specimen has been injected, and that does not stick and glue together as do bismuth suspension and some other media.

A REVIEW OF THREE YEARS' WORK AND ARTICLES ON PNEUMOPERITONEUM*

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In accepting the task imposed on him by our president, your essayist finds himself in a more or less embarrassing position in undertaking to sum up the present status of artificial pneumoperitoneum as a diagnostic aid. It is universally conceded that the development of this diagnostic procedure, so brilliantly perfected by Stein and Sewart, marks one of the milestones in roentgenological progress. In reviewing the results of the experience of most of the men doing this type of diagnostic work, including several who are not members of this society, your reviewer does not wish to perhaps discourage the employment of one of the most strikingly helpful roentgenological means perfected within five years; neither by maintaining a discreet silence can he conscientiously withhold information relating to some phases of danger associated with the method.

In the effort to study the question from an unbiased point of view, gathering data from every available American source, circular letters of inquiry were prepared and sent to 223 workers, from whom 131 replies were returned. Of the 131 replying, 47 (among whom were included the names of some of the most prominent members of our society) stated that they had had no experience, while 63 more declared that their experience was too limited to warrant an expression of opinion. Twenty-one had had sufficient experience to enable them to formulate replies to the inquiries regarding dangers, inconveniences and contraindications, and to sum up their notion of the field of usefulness of pneumoperitoneum. Special inquiry was made concerning the safety of this measure as an office diagnostic procedure.

It seems generally agreed that the method must be pursued with due regard to the necessities of an aseptic surgical operation, excluding from the examination such cardiac or respiratory cases as would ordinarily be considered bad surgical risks; that the gas used should be carbon dioxide or a mixture of carbon dioxide and oxygen; that the amount of gas introduced should be carefully estimated; that the injection be done slowly, while the patient is carefully observed for signs of untoward effect. And indeed a review of the experience of the men who have answered the questionnaire warns of the serious dangers and inconveniences if these precautions are not followed, if indeed serious mishaps may not occur in spite of all precautions.

INCONVENIENCES

It seems unanimously conceded that pneumoperitoneum is not a popular procedure with the patients. It is true that the distress seems to be largely psychic in many cases, but too often the pain is very real, requiring the administration of morphia. Many of the patients complain of nausea; some vomit. The majority show respiratory distress evidenced by dyspnea and a feeling which they describe as shortness of breath. Some patients sweat profusely after the examination. When carbon dioxide has been used, it is true that the symptoms are usually dissipated within a few hours, although it is not uncommon to note their persistence long after the distention of the abdomen has been relieved. Certainly no patient thus examined recalls the experience as pleasant. There is a further objection that the method is time-consuming, and the cause of considerable inconvenience in the roentgen laboratory.

It should be stated that there is a marked difference between the discomfort experienced by the patient when only a small amount of gas has been introduced into the peritoneal cavity, as in the method advocated by Rubin and Peterson, where the chief aim of the study is to determine the patency of

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D.C., Sept. 27-30, 1921.

the tubes and other data relating to the pelvic organs, in comparison with the distress experienced after massive inflation of the abdomen for the purpose of general abdominal diagnosis.

Aside from the distress, the list of inconveniences which we have been able to enumerate seem to be dependent upon errors of technique which it should be possible to avoid, but which experience shows are not always avoided, even in the best clinics: viz., interstitial emphysema, which may naturally be avoided by making sure that the needle is within the abdominal cavity before turning on the gas; sudden overdistention, not likely when gas measuring devices are employed; persisting overdistention, usually, but not always, relieved by deflation, or better still by the employment of carbon dioxide in place of oxygen.

Yet several of our reporters state that they have had patients whom they could not deflate, and where the pain following the examination could not be controlled by large doses of morphine. These patients, it appears, were for the most part suffering from peritoneal adhesions. Certain it is that the patients complaining the most bitterly of pain have been patients in whom the presence of adhesions seemed indubitable. Many patients whose examination has later been followed by operation, have expressed the opinion that the discomfort experienced after operation was more easily borne than the distress attending gas inflation of the abdomen.

DANGERS

Dangers which have been enumerated include the following: Intestinal puncture; puncture of omental or mesenteric blood vessel; puncture of dilated ureter, bladder, or other abdominal viscus; peritonitis; air embolism; superficial emphysema; rupture of malignant adhesions; precipitation of cardiac failure through overdistention of the abdomen. Practically every one of the dangers just enumerated has been foreseen, and the pioneers in pneumoperitoneum have made rather thoroughgoing experimental observations in the effort to predetermine the amount of danger actually imposed upon the patient. At first, it seemed fairly assured that such untoward effects were not going to be encountered; but gradually reports have been coming in until now we have accumulated an impressive list of accidents which have actually occurred in the hands of men for the most part recognized as well qualified by training and equipment to do this work properly. The dangers, as above listed, together with remarks concerning them will follow seratim.

Intestinal Puncture. In at least one case the intestine was punctured and gas introduced into the small intestine in a patient who had not had any previous surgery, and in whom there was no reason to suspect adhesions of the intestine to the anterior abdominal wall. Fortunately the introduction of gas in this case was proceeding under fluoroscopic control; the fact of intestinal puncture was almost immediately recognized, and the needle withdrawn instantly. No untoward effects resulted in this case, though the patient was kept in bed for three days, under careful observaton. Another case is recorded where the puncture of adherent intestine was proven by the beautifully outlined air-distended colon shown in the roentgenogram, without the usual evidences of gas in the peritoneal cavity. Another reporter related a case where colon was adherent to the abdominal wall from cecum to splenic flexure, the adhesions also involving several loops of jejunum. The needle entered the lumen of the intestine and great distress followed. Details as to the nature of the complications were not given. It is without doubt possible to puncture the bowel during the introduction of the needle, though the writer has yet to learn of a fatality from this cause.

Puncture of Omental or Mesenteric Blood-Vessel. The possibility of this danger is often mentioned. One reporter states that in a great many laparotomies a needle was inserted before the abdomen was opened. In one case, it was found that from one of the mesenteric vessels, there had occurred a fairly large hemorrhage which might have given some trouble if the abdomen had not been opened within a short time.

Puncture of Abdominal Viscera. In a discussion on a paper before the Section on Urology at the last meeting of the American Medical Association, Sante relates a case

of death following an attempt at pneumoperitoneum, death being due to the injection of oxygen directly into the spleen. As the reporter stated, this case was manifestly an error; but these errors should be reported, and should be taken into due consideration in appraising the value of the procedure. The urinary bladder has been punctured at least once. In another case, in the hands of a well known urologist, an examination was being conducted in a case where no special tests were needed to recognize an enormous hydro-ureter. The urologist thought it would be unique to procure roentgenograms of this case after distending the peritoneum with gas; but, although an experienced surgeon introduced the needle far to the opposite side of the midline, fully confident that he would avoid puncture of the urinary system, he evacutated several pints of urine through the pneumoperitoneum needle. No harm resulted, for which all concerned were duly thankful; no one would knowingly repeat the experience.

Peritonitis. Barringer, of the Memorial Hospital, New York, is responsible for the report of one fatality following air inflation of the peritoneum in a patient with carcinoma. The injection was made with all due regard for asepsis, but some days after the injection the patient died. Dr. James Ewing, who performed the autopsy, reported a generalized peritonitis, the infection manifestly entering by way of the needle. It was admitted that this patient, because of his advanced carcinoma, was probably peculiarly susceptible to infection.

One of the senior surgeons in the largest surgical clinic in the world recently published a statement that wound infection occurred in about ten per cent of their clean wounds, and this in spite of every precaution known to science. It is presuming too much to expect that abdominal puncture for pneumoperitoneum can proceed month after month in scores of cases, without sooner or later recording more than one instance of peritonitis.

Even with the employment of the transuterine route there is danger of waking up latent infection and the cases must therefore be carefully selected. One case is reported wherein a young married woman, in whom a careful history and examination by the gynecologist gave no sign of tubal infection or obstruction, transuterine pneumoperitoneum revealed patency of at least one tube and a left ovarian cyst. A laparotomy was performed the following day for removal of the dermoid, the tubes and remaining ovary being noted as normal. Two days later the patient developed a definite right salpingitis with, shortly after, extension to the left tube, followed by prolonged and painful convalescence.

Air Embolism. This is a real danger. At least one death and probably two, may be thus explained. These cases are briefly related in a later paragraph recounting the known deaths in conection with this method of diagnosis. Another case is reported in which death was escaped by a narrow margin, where it is reasonable to believe that there may have been a small amount of air injected into a vein. It is now recognized that a small air embolism may not prove fatal or even cause any symptoms; however, none of us cares willingly to permit such an injection. If one takes the precaution to make sure that no blood escapes from the cannula after removal of the trocar, there will be little danger of this accident.

Superficial Emphysema. This is a distressing and confusing accident—confusing so far as the diagnostic value of the resulting roentgenograms is concerned—but no case has been reported in which harm has resulted. Of course, this is also a fault in technique but its occurrence is confessed by some of the men with the largest experience in this method.

Rupture of Malignant Adhesions. It is conceivable that abdominal overdistention might tear loose some types of malignant adhesions and thus awaken renewed virulence in some more or less latent malignancy. This danger is mentioned by a number of our reporters, in the hands of one of whom this sequence of events was followed by a rapidly fatal outcome. The writer is not inclined to consider this danger as a serious drawback to the method.

Precipitation of Cardiac Failure. This rather serious danger is a real one. One of our most enthusiastic advocates of pneumoperitoneum has suspended the employment of this procedure because of a near fatality in a case of this sort. The patient was a well pre-

served man of sixty who was very anxious to determine whether or not he had gall-bladder disease. A few moments after introducing the usual amount of CO_2 the patient became exceedingly distressed and markedly cyanotic, his pulse was imperceptible, and no heart-beats could be heard with the stethoscope for a period of several minutes. It certainly looked as if the man were dying, but he recovered during the next twenty minutes. He was rather groggy for the rest of the afternoon, but this may have been due to the morphine which he received before the work began. The man possessed a very nervous make-up, but his blood pressure was normal and his heart appeared to be normal. The physician discovered later that on two or three occasions the patient had had sudden attacks of syncope during which he became unconscious and during which he vomited. Nevertheless the experience was so harrowing, our reporter felt that he would not care or dare to run the risk again unless the experience of many others showed the technique to be as safe as it had seemed to him in the past.

Another reporter related a case when with only the usual amount of abdominal distension, the exact measurement of the quantity of gas not being recorded, a woman patient went into a state of profound shock, from which she was revived only after an afternoon and night of anxious effort.

It is obvious that cases of inefficient myocardium, valvular heart lesion or other cardiovascular weakness should only exceptionally be subjected to this method of study.

DEATHS

Four deaths, directly associated with pneumoperitoneum have come to your reviewer's notice. Two have already been related, one due to introduction of oxygen into the spleen, and one due to peritonitis. Two further cases will now be related under this miscellaneous heading, inasmuch as there is some difference of opinion as to the exact cause of death, though both are undeniably associated with an attempt to examine by the pneumoperitoneum method.

The first of these two cases comes from one of the best known medical institutions in the world, where it cannot be doubted that all reasonable precautions were taken to avoid danger to the patient. A young woman of thirty-five had undergone a very thorough clinical study of her case to discover the cause of weakness, loss of appetite, headache and enlargement of the abdomen. A mass could be seen and palpated in the epigastric region reaching below the umbilicus, more marked on the right side. It was irregular and hard to palpation, and rather tender. The liver edge was felt 4 cm. below the costal margin; the spleen was not palpable. Pneumoperitoneum was proposed and carried out half an hour after the hypodermic injection of morphine 1/6. A small amount of novocaine, ½ per cent strength, was used for local anesthetic. The skin was incised with a scalpel and a small needle introduced into the free peritoneal cavity. Oxygen and CO_2 bubbled through sterile fluid in a bottle fitted with a three-way stopper. The gas had just started to bubble through the fluid, only a few c.cm., when suddenly the patient became cyanotic and the hands, especially the left, went into the position of tetany, whereupon the needle was immediately withdrawn. The pulse became extremely weak and could not be felt at the wrists. The heart sounds slowed to 30 or 40 per minute, as heard with the stethoscope, and were much weakened. Respiration practically ceased. Artificial respiration was given as well as atropin and adrenalin intravenously. After twenty or thirty minutes, the heart rate would suddenly jump to 130 or 140; then suddenly drop to about 40. There was gradual improvement in respiration and heart rate until at the end of an hour the pulse was 120 and respiration 18 to 20. The patient was not conscious. After four hours the pulse was 102, with some extra systoles, respiration 30, temperature 99. Occasional movements of arms and eyelids were noted but no return to consciousness. On the following afternoon, the pulse averaging 100 to 110, respiration being fairly normal, the patient suddenly experienced an attack similar to the one of the previous day. She became cyanotic, the pulse failed at the wrist, respiration ceased, and the end came very quickly, just twenty-four hours after the attempt at pneumoperitoneum. No post mortem examination could be obtained. At the time the normal rhythm was resumed, about two hours after the examination was

started, there was heard a most unusual sound over the base of the heart, characterized by the clinicians as a gurgling, loud systolic sound, very superficial, just "under the ear". This continued for 15 to 20 beats, grew gradually fainter, and then disappeared. The final diagnosis was: Possible air embolism, gumma of the liver. Simple heart block would not explain the continued unconsciousness after the resumption of normal rhythm.

The fourth fatality of which I have record occurred at the beginning of an injection for the performance of artificial pneumoperitoneum. The patient, sex not given, was fifty years old, with a clinical diagnosis of splenic leukemia. Gastrointestinal study by the barium meal showed the stomach displaced slightly toward the median line by a mass in the left upper quadrant of the abdomen, probably splenic. It was decided to do a splenectomy. Artificial pneumoperitoneum was requested to determine the presence or absence of adhesions between the spleen and the diaphragm. The patient was prepared in the usual manner, and the surgeon inserted the paracentesis needle. Oxygen was employed. In less than one minute after the gas was turned on the patient suddenly became cyanotic and unconscious. Respiration was stopped. The needle was at once withdrawn but in spite of every effort the patient died within five minutes of the time of the insertion of the needle. The quantity of gas which had passed into the peritoneal cavity was very small—so small that no distention was noticeable. The needle had been passed by a surgeon who had done a number of injections previously. Here too, unfortunately, the exact cause of death was not determined. The reporter of this case felt that it was not due to any factor pertaining to the procedure itself, but rather to a cause which might have been active during the course of paracentesis abdominis for any other purpose. The surgeon had observed in this case that the patient was extremely apprehensive and fearful on entering the hospital that morning. Clinical examination revealed no evidence of serious cardiac derangement prior to the attempted pneumoperitoneum; the patient was ambulant up to the time of his entering the hospital. In your reviewer's opinion, this case is exactly analogous to the preceding.

There were probably other deaths to report in this connection, for two of the four just recited were stumbled upon from sources other than those circularized. They furnish abundant food for thought, and incontestably mark the procedure of artificial pneumoperitoneum as one which should be performed only in an institution fully equipped for surgical operations and emergencies, by men ready to assume at once the responsibilities of dealing with such emergencies should they arise. It is interesting to note that in three exactly similar accidents, two of them fatal, characterized by sudden cyanosis, unconsciousness, suspension of respiration and alarming cardiac disturbance, oxygen was used in one, carbon dioxide in another, and a mixture of carbon dioxide and oxygen in the third.

It is only fair in this connection to recall the dangers associated with several other established diagnostic means such as spinal puncture and pyleography. Neither of these is an absolutely safe procedure; accidents have been recorded with both, and possibly some fatalities. Both procedures are often followed by unpleasant experiences on the part of the patient. Neither of them is performed as a routine examination, nor are they recommended without due consideration of the contraindications, and the real necessity for their employment.

However, the fatal or alarming attacks above related in connection with attempted pneumoperitoneum have a striking similarity in the details of their symptoms and in the lightning rapidity of their onset; and few of us will be able to assist at future examinations by this method without a vivid consciousness of the possible dangers.

Undoubtedly some of the accidents above recited are the result of errors in technique; yet these errors have occurred in some of the foremost medical and surgical clinics of the world, in the hands of men recognized as able to avoid such errors if indeed it is possible always to avoid them. We may therefore assume that such errors are likely to recur from time to time in spite of all our foresight and precaution.

INDICATIONS

In general, it may be stated that pneumoperitoneum is definitely indicated in a se-

lected class of cases of obscure abdominal or retroperitoneal conditions, where the careful use of all other clinical means has failed to elucidate the problem with any degree of satisfaction and where an exploratory operation does not seem preferable. Such conditions relate especially to lesions of the diaphragm other than subphrenic abscess, and obscure retroperitoneal lesions. Certain lesions of the kidney and their differentiation from paravertebral masses are especially illuminated by this method, but the opinion is frequently offered that where the method has been used in urological work, it has only occasionally added to the data already secured by other roentgenological or urological diagnostic means. The perfection of the Potter-Bucky diaphragm has been one of the most important factors in still further narrowing the field of usefulness of pneumoperitoneum, for good roentgenograms made with the Potter-Bucky diaphragm show a wealth of detail only surpassed by plates made after gas inflation of the abdomen. Many laboratories have adopted the plan of trying the Potter-Bucky diaphragm technique before resorting to pneumoperitoneum, with the result that the latter is frequently not needed.

Abdominal ascites presents the least contested indication for the introduction of gas, which is so easily and safely carried out in this type of cases. The method is probably next most useful to the gynecologist, especially when minimal amounts of gas are introduced by transuterine insufflation.

Abdominal adhesions at first seemed to offer the most tempting indication for pneumoperitoneum, especially that class of cases where the patient developed a clinical picture not present before operation. But post-operative adhesions are very common; probably a very small proportion only cause symptoms which bring the patient to the roentgenologist. When a patient develops a new train of symptoms following abdominal section, the surgeon is frequently assured, without special roentgenologic study, that adhesions are responsible; but the only type of adhesion for which he is likely to operate are those involving attachment of the small intestine to the abdominal wall or to some fixed viscus. Adhesions of intestine to the abdominal wall are sometimes most strikingly demonstrated by pneumoperitoneum.

The question may properly arise whether it is not possible to go too far in our effort to complete a diagnosis; and whether there does not remain a certain field for the exploratory operation. Your reviewer realizes that he has stood in a difficult position in making this appraisal of the value of pneumoperitoneum. It is hard to subtract the individual factor and make the appraisal impersonal. The opinions expressed are distinctly not original in your reviewer's mind, although he finds himself in accord with them; they are gleaned from hundreds of pages of correspondence with men of large experience most likely to be able to furnish information.

DISCUSSION

Dr W. H. Stewart. We are grateful to Dr. Case for gathering all of this interesting data. Unfortunately, our President has selected a man to obtain this information who, we feel, is distinctly surgical in his tendencies. We all recognize his ability as a surgeon, as well as a roentgenologist. It has been difficult to convince a certain class of surgeons throughout the country as to the practical value of pneumoperitoneum. We fear Dr. Case comes within this class. One can freely say, however, that he has treated the subject in a fair manner.

It must be remembered that we have had many difficulties in placing this method before the medical profession of this country. The same difficulty was met with when spinal puncture was introduced; this has been overcome and we feel the prejudice against pneumoperitoneum will, in a great measure, disappear.

If we accept a mortality of four cases since the method was introduced, one can be quite satisfied, considering the number of patients that have been examined and also the fact that in many instances the inflation had been performed by the inexperienced. We are accustomed to surgical mortality, but death from any new procedure is not accepted so readily. It is difficult to appreciate a death from puncture of the spleen or from infection, if proper surgical precautions are used. Unfortunately the post-mortem findings could not be obtained in the other two cases, one can, therefore, never feel sure that pneumoperitoneum was the cause of death.

In advocating this procedure, we have always warned against its indiscriminate use. The inflation should be done by a surgeon and

not by a roentgenologist, unless he has had special surgical training, and the method should never be used except in cases where the information cannot be obtained by the ordinary methods of examination.

We have never felt that it was necessary to measure the gas; one must use judgment as to the quantity. Relaxation of the abdominal walls prevents a uniformity to the dose, and massive inflation is not advisable; not much gas is needed. At first, when oxygen was used, we distended the abdomen to a considerable extent; this we have since found is unnecessary. The abdomen should be distended to a full dome shape, and with the least possible amount of tension. The more the abdominal cavity is distended, the more danger of pain and dyspnoea. Since we have been using morphine with carbon dioxide, the patients have had very little pain or distress. In all of our series, over one hundred and fifty, we have never had one with any serious trouble.

We have never considered the danger of puncturing the intestines, owing to the fact that if one goes about 3 cm. below the umbilicus, he will never have any difficulty, especially if the abdominal wall be somewhat relaxed, and can be raised from the intestines.

While in Germany this summer I had the pleasure of hearing a paper by Goetze, who is probably one of the most ardent advocates of the method. He turns the patient on the side and punctures in the left or right iliac fossa.

Dr Case (closing the discussion). I did not choose this subject and I do not want for a moment to give the impression that I am trying to kill the method. I consider artificial pneumoperitoneum one of the most brilliant accomplishments in the last five or six years of roentgenological development. It has a very definite field. I expect to go on using it for a certain number of cases. These instances, however, will be puzzling cases involving the diaphragm (where this method has its supreme value) and in the study of retro-peritoneal masses. A very helpful point of technique in the latter type of case is to put the patient in the knee-chest position, after the introduction of gas, thus allowing the intestines to fall away from the spine. The lateral roentgenogram made under these conditions is strikingly helpful, as has been especially demonstrated by Sante.

Dr Stewart is mistaken; there were five deaths, but he admitted only two. It is hard in one of these pneumoperitoneum cases to convince the hospital staff or the patient's family that death was not due to the pneumoperitoneum. In three of the cases surgeons did the pneumoperitoneum; in another an interne did it.

I used the term "massive inflation" in contradistinction to the term introduced by Rubin of "minimum" or "minute" inflation. It is not necessary to pass more than a small quantity of gas through the uterus. By massive inflation I meant the term as Dr. Van Zwaluwenburg used it.

A member of our society introduced the use of CO_2; used it in a very large number of cases; then reported a near-fatality and now declares he will not use the method again until it is demonstrated safe to use it. Recognizing the dangers, I personally expect to go on using the method in a limited way. It is not my purpose to say we should not use it. I simply call attention to the dangers. The roentgenologist must protect himself by having the inflation done in an institution and by recognizing the limitations of the method. It was suggested by one member of our society that the use of pneumoperitoneum, or rather the frequency of its use, will be in inverse proportion to the degree to which other clinical means have been exhausted.

Comparing exploratory operation and pneumoperitoneum, exploratory operation is usually done under a local or gas anesthetic. It is not a serious affair provided nothing more is done than to explore, and we are considerably more sure in our diagnosis than by pneumoperitoneum. There is a certain amount of pain, for which we give morphine; that is done in pneumoperitoneum. Half a gram altogether is the maximum I ever give to a patient; usually less. When using gas anesthetic, 50 per cent are not nauseated; using local anesthetic, there is no occasion for any nausea. In exploratory operations I do not think there should be more than ½ per cent mortality, and that should not occur in purely exploratory operations.

The exploratory operation has a distinct advantage in that after you have made your diagnosis you will, in a large per cent of cases, go ahead and attend to it without subjecting the patient to further mental or physical discomfort.

I would like to ask Dr. Van Zwaluwenburg one question. We will admit difficulty in making a correct gynecological diagnosis in heavy patients. Naturally the use of pneumoperitoneum is invoked as a means of eliciting a diagnosis. How many times has he observed surgeons leave a pelvic pathology in the pelvis, whether they found their diagnosis was correct or incorrect? In other words, it matters little,

as far as the surgical indication is concerned, whether we differentiate between a tubal or an ovarian mass in the great majority of cases.

I would like to suggest that the term "exploratory operation" be not used. We call it surgical examination. Surgical examination does not promise the patient anything (neither does pneumoperitoneum) in the way of relief.

I want to reiterate that there is a definite field for this pneumoperitoneum work. I want to emphasize the use of the Potter-Bucky diaphragm, which will obviate the necessity of pneumoperitoneum in a large percentage of cases.

OBSERVATIONS ON THE NORMALLY DEVELOPING SHOULDER*

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THE study of the shoulder has been carried out in a manner similar to the studies made on the elbow and knee.

One is encouraged to continue these studies by such quotations as the following taken from an article by Bowen.[1]

"Experience leads me to the belief that clinically, actual diagnosis of separation of an epiphysis, as distinguished from a fracture is practically unusual. Given a fracture close to an epiphysis, one may, with the patient's age known, make a shrewd guess."

A tribute is paid to the work of Poland which the author says is remarkable for its completeness. This work which should have been so useful is now out of print.

The study has been divided into three parts:

(1). A review of the literature.

(2). Observations based on a study of normal shoulder joint.

(3). Descriptive findings of individual radiograms of normal joints at various ages.

PART I

REVIEW OF THE LITERATURE

It is not necessary to review again the general literature of epiphyseal separation as this was done in the original paper.[2]

Piersol, in his work on anatomy states: "There are two or three (centers) for the upper, a chief one for the head coming soon after birth and sometimes sooner.

"In the third year ossification begins in the greater tuberosity, and another point may appear somewhat later in the lesser one.

"At five all of the centers for this end may become one, making a cap for the top of the shaft, which later extends into the head. The upper end joins at about nineteen, the line of union being lost at twenty or twenty-one."

Gray's "Anatomy" gives the following: "During the first year, sometimes before birth, ossification commences in the head of the bone and during the third year the center for the tuberosities makes its appearance, usually by a single ossification point, but sometimes, according to Beclard, by one for each tuberosity, that for the lesser being the smaller and not appearing until the fifth year." "By the sixth year the centers for the head and tuberosities have increased in size and become joined, so as to form a single large epiphysis."

"The upper epiphysis is not united until the twentieth year." Preston's work on fractures[3] is in complete agreement in word and sentiment with Gray's "Anatomy."

Stimson states: "The upper *epiphysis* of the humerus comprises the head and the tuberosities."

*I wish to express my appreciation of the kind cooperation and assistance in this work of Drs. Paul G. Lacroix and I. M. Gage of the surgical staff of Touro Infirmary, as well as to Drs. Samuel and Bowie of the Department of Radiology. Particular mention should be made of the splendid cooperation and interest in the work manifested by Mr. Goodman, technician in the Department of Radiology.

Comment. It is interesting to note that Stimson speaks as though he believed that there was a single epiphysis.

Cotton does not venture an opinion on the subject under the heading "Separation of the Epiphysis" (humerus) in his work on "Dislocations and Joint Fractures."

In Morris's "Anatomy" we find: "Single centers appear for the head in the first year, for the greater tuberosity in the third year and for the small tuberosity in the fifth year, though sometimes the latter ossifies by an extension from the greater tuberosity. These three nuclei coalesce at six years to form a single epiphysis which joins the shaft about the twentieth year."

Lewis's Gray and Spitzka's "Anatomy" as well as Gerrish's "Anatomy" agree in every detail with the above.

Cunningham[4] states: "Within the first six months after birth a center usually appears for the head; this is succeeded by one for the greater tuberosity during the second or third year. These soon coalesce and a third center for the small tuberosity begins to appear about the end of the third year or may be delayed until the fourth or fifth year.

These three centers are all blended by the seventh year and form an epiphysis which ultimately unites with the shaft about the age of twenty-five."

According to Eisendrath[5], "The upper epiphysis joins the shaft at the age of twenty."

Williams[6] in a chapter on "Development of the Skeleton" does not mention particular ages at which union of the epiphysis and shaft takes place. No pictures are given. Von Bergmann, Senn, Park and many other recent standard works on surgery were consulted for information and nothing was found that would be helpful on this subject.

Choyce gives the following: "The upper end of the humerus is formed of three separate epiphyses, for the head and greater and lesser tuberosities, the centers for which appear respectively at six months, two years, and three years after birth. They are all united at the end of the second year to form a single epiphysis which joins the shaft, at the age of twenty-five.

Roberts and Kelly state: "The humerus is developed from a center of ossification for the diaphysis, which appears during the eighth week of fetal life, and six or seven secondary centers for the extremities which appear after birth, the epiphysis being cartilaginous. During the first year the centers appear in the following order:—upper epiphysis for the head, the capitellum, the greater tuberosity, the lesser tuberosity, the trochlea, the external and internal epicondyles, which appear between the tenth and twelfth years. Complete ossification and disappearance of the synchondroses from the twentieth to the twenty-second year."

PART II

OBSERVATIONS

When examining roentgenograms of the shoulder in the young, one must know how many separate epiphyses are normally present, when each one begins to ossify and when complete ossification and union take place.

Pictures of the shoulder girdle include the upper limit of the humerus, the scapula, and the clavicle.

We have observed one definite epiphysis for the upper end of the humerus and possibly a second, corresponding to the greater tuberosity of the humerus and one for the acromion process.

The earliest observation which we have made is at the age of seven weeks; at this time there is only one epiphysis, which corresponds to the head of the humerus; this is elliptical and it is rather widely separated from the upper limit of the shaft, which resembles a double inclined plane. At this time the glenoid fossa, the acromion process and the clavicle are ossified in the same degree as the diaphysis of the humerus. There is no evidence of the coracoid process at this time.

During the first two years no other epiphysis appears to be ossifying. The epiphysis for the head almost doubles its size and approximates more closely the shaft. There is at this time a small shadow representing the ossifying coracoid process.

At three years of age the upper epiphysis has increased very much in size and a new shadow is seen to the outer side of the original elliptical shadow for the head, the new shadow being a smaller ellipse than the ori-

Table I

OSSIFICATION IN UPPER EPIPHYSIS

Author	*Head*	*Greater Tuberosity*	*Lesser Tuberosity*	*Union with Shaft*
Piersol	Soon after birth (At five all	Third year have united to form	Later than third year one epiphysis)	Twenty to twenty-one
Gray	During first year (All coalesce to epiphysis)	Third year form a single	Third year. Sometimes as late as the fifth or sixth year.	Twentieth year
Morris	First year (All coalesce to epiphysis at six)	Third year form a single	Fifth year. Sometimes this is an extension of the greater tuberosity.	Twentieth year
Lewis Gray Spitzka Gerrish	Same as above			
Cunningham	During first six months	Second or third year	Third to fifth year	Twenty-five
Eisendrath				Twenty
Choyce	All unite by the second year Three separate epiphysis Six months	Two years	Three years	Twenty-five
Preston	Gives the same as Gray's "Anatomy."			
Roberts and Kelly	First year	First year	First year	Twenty to twenty-two
Cohn	Radiologically there is only definite epiphysis. Ossification is certainly evident at seven weeks after birth. Complete union with the shaft takes place between the nineteenth and twentieth year. The greater tuberosity seems to be a downward growth from the head. In none of our pictures have we been able to see a separate center of ossification for the lesser tuberosity.			

ginal. It is difficult to say whether this represents ossification within a separate center or whether it is a downward and outward growth from the head. In either event the cap formed by the above described shadow forms a groove and tongue joint with the shaft. The coracoid has now become a distinct shadow.

Few important changes in general are evident until the seventh year; at this time the upper epiphysis for the head and the greater tuberosity are certainly one.

By the eighth year almost complete ossification has taken place in the epiphysis and we find it closely approximated to the shaft. The coracoid has also increased greatly in size.

A peculiar picture is presented at nine years and ten months (Fig. 10). Examining it carefully one finds that there is a constriction below the head and lower down on the picture, there is a definite wedge-shaped "fragment". It was difficult to interpret this particular appearance until it was realized that possibly it might be due to two things, position and an optical illusion.

In order to determine if the apparent lines were due to position and nothing else it was determined to take the same shoulder in several positions. These proved conclusively that the appearance is an optical illusion, the result of looking through the epiphysis at different angles (Figs. 20, 21 and 22).

From this age until nearly the fifteenth year few changes are noted, except a progressive enlargement and ossification of the epiphysis.

At the age of fourteen years and six

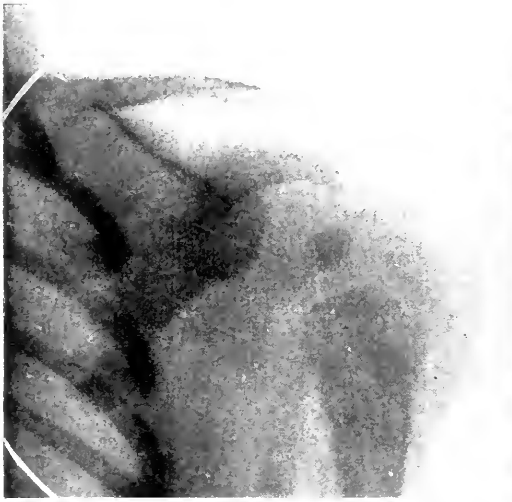

FIG. 1. Normal shoulder. Age: 7 weeks.

FIG. 2. Normal shoulder. Age: 5 months.

FIG. 3. Normal shoulder. Age: 5 months.

FIG. 4. Normal shoulder. Age: 13 months.

FIG. 5. Normal shoulder. Age: 2 years.

FIG. 6. Normal shoulder. Age: 3 years.

FIG. 7. Normal shoulder. Age: 4 years, 7 months.

FIG. 8. Normal shoulder. Age: 7 years.

FIG. 9. Normal shoulder. Age: 8 years.

FIG. 10. Normal shoulder. Age: 6 years, 10 months.

FIG. 11. Normal shoulder. Age: 11 years, 6 months.

FIG. 12. Normal shoulder. Age: 14 years.

months we note a definite center of ossification for the acromion process. This is very important because this epiphysis is often mistaken for a fracture. At this time also we note that the greater tuberosity of the humerus shows a distinct line which might be mistaken for a fracture (Fig. 14).

At the age of eighteen years and seven months (Fig. 18) all of the epiphyses are united to the shaft—there being only the slightest line of demarcation at the lower level of the greater tuberosity of the humerus; this line is irregular and may extend through the diameter of the shaft.

By the twentieth year all of the epiphyses are completely ossified and the shoulder has the appearance of the adult normal type.

PART III

INTERPRETATION OF NORMAL SHOULDER PICTURES AT VARIOUS AGES

Age: Seven Weeks (Fig. 1). At this time there is one epiphysis for the upper end of the humerus and this is a small elliptical mass widely separated from the shaft. The acromion process, the glenoid fossa and the clavicle are all well ossified. There is no evidence of a coracoid process.

Five Months (Figs. 2 and 3). The only change that is noted is a marked increase in the size of the upper epiphysis, which is now at least twice the size of the same shadow at seven weeks.

Thirteen Months (Fig. 4). The upper epiphysis has increased in size. No other changes are noted in the other structures.

Two Years (Fig. 5). The only evident change is a small shadow which may be the beginning of ossification within the coracoid.

SUMMARY

During the first two years ossification is noted in one epiphysis for the upper end of the humerus. The other structures showing evidence of ossification are all of the prominences of the scapula, except the coracoid which only shows slight evidence of ossification toward the latter part of the second year.

Three Years (Fig. 6). The upper end of the shaft has changed its appearance, from the transverse line, to an angular appearance, sloping downward and outward and downward and inward from a plane passed through the outer third of the shaft of the humerus. The inner slope of this upper end of the shaft is covered in about two thirds of its upper aspect by the ossified upper epiphysis. There is a shadow in the outer portion of the epiphysis, which seems to make the epiphysis fit over the tongue and grooved effect of the shaft.

This shadow in the outer portion of the upper epiphysis may be a separate epiphysis for the greater tuberosity or it may be a downward projection of the upper epiphysis to form the greater tuberosity as a portion of the original epiphysis for the head.

The coracoid by this time has grown to a rather large size.

Four Years and Six Months (Fig. 7). The upper epiphysis covers more than two thirds of the upper end of the diaphysis. The tongue and groove effect is more evident now than at previous periods. If the ossifying portion of the upper epiphysis which forms the greater tuberosity is a separate epiphysis, there is certainly no definite line of demarcation between the two.

Seven Years (Fig. 8). The upward projection of the diaphysis is entirely covered by the ossified upper epiphysis. If originally there were separate epiphyses for the head and greater tuberosity the two have certainly united at this time.

Eight Years (Fig. 9). There is closer approximation between the shaft and the epiphysis. Ossification from the shaft seems to proceed up into the epiphysis. The coracoid process is larger than in previous years.

Nine Years and Ten Months (Fig.10). The diaphysis seems to be separated from the epiphysis for the head, by a triangular or wedge-shaped shadow. The impression given is that this wedge is separate and distinct from the shaft and also from the head.

This is not the true state of affairs but the appearance is rather an optical illusion due to the position of the arm when the picture was taken.

The lower part of the head represents the epiphyseal line and what afterwards becomes the anatomic neck.

The wedge-shaped shadow represents the greater tuberosity.

FIG. 13. Normal shoulder. Age: 14 years, 6 months.

FIG. 14. Normal shoulder. Age: 14 years, 8 months.

FIG. 15. Normal shoulder. Age: 15 years, 4 months.

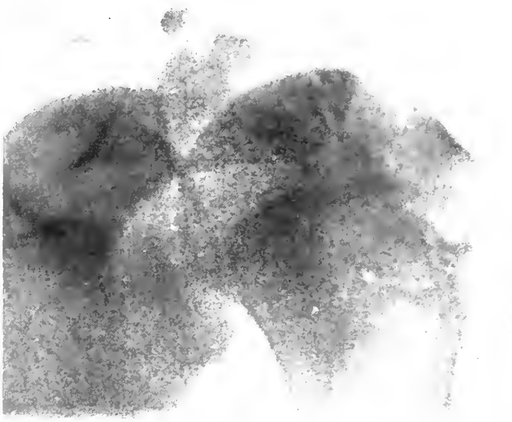

FIG. 16. Normal shoulder. Age: 16 years, 10 months.

FIG. 17. Normal shoulder. Age: 17 years, 6 months.

FIG. 18. Normal shoulder. Age: 18 years, 7 months.

FIG. 19. Normal shoulder. Age: 20 years.

FIG. 20. Normal shoulder.

Eleven Years and Six Months (Fig. 11). There is closer approximation between the shaft and the epiphysis. At this time there is no evidence of union within the epiphysis of the acromion process.

Fourteen Years (Fig. 12). There is closer approximation of epiphysis and diaphysis, but no evidence of ossification between the two. The coracoid process is well developed. There is still no evidence of ossification of the epiphysis for the acromion.

Fourteen Years and Six Months (Fig. 13). This is similar to the appearance at fourteen years, with the exception that there is a well developed acromion process. The epiphysis is separated by a definite line from the acromion proper.

Fourteen Years and Eight Months (Fig. 14). There is complete ossification of the upper epiphysis of the humerus, almost complete obliteration of the epiphyseal line, except the lower portion of the greater tuberosity which is still separated by a well defined line.

At this age, the acromion epiphysis seems completely ossified and united to the remainder of the acromion. This is an occasional finding.

Fifteen Years and Four Months (Fig. 15). The wedge-shaped appearance of the upper end of the shaft is here replaced by an almost flat top of the shaft, superimposed on which is the ossified upper epiphysis which is not united yet to the shaft. The acromion is not united to its epiphysis, although the epiphysis shows evidence of almost complete ossification.

Sixteen Years and Ten Months (Fig. 16). The greater tuberosity seems not to be united entirely with the diaphysis. Between the remaining portion of the epiphysis and diaphysis union seems complete.

The epiphyseal line between the acromion and the diaphysis of the scapula is still very marked.

Seventeen Years and Six Months (Fig. 17). Incomplete union of the epiphysis and diaphysis. The acromion process is not yet united to the shaft.

Eighteen Years and Seven Months (Fig. 18). Complete ossification of the epiphysis and almost complete union of the epiphysis and shaft. Scapula ossified throughout.

Twenty Years (Fig. 19). Complete ossification and union of the respective epiphyses and diaphyses.

CONCLUSIONS

Radiologic examination of the shoulder girdle during the first year shows only one epiphysis sufficiently ossified to leave a shadow, the epiphysis for the upper end of the humerus. This epiphysis is represented by a small elliptical shadow, which is rather widely separated from the upper end of the shaft. Our earliest observation was seven weeks.

During the first two years no other epiphysis makes its appearance, except for a

FIG. 21.

FIG. 22.

Figures 20, 21 and 22 represent the altered radiologic appearance of the same shoulder, caused by a change in its position.

small shadow which may be interpreted as the early ossification within the coracoid process.

During the third year the head of the humerus increases rather rapidly in size. The upper end of the shaft takes on the appearance of a double inclined plane, higher near the middle and sloping downward to either side.

At this time there is a shadow on the outer and lower aspect of the epiphysis for the head, which may be ossification within a separate epiphysis for the greater tuberosity or it may be that the greater tuberosity is a downward growth from the original epiphysis for the head. In the pictures no clear line of demarcation can be made out between the shadows.

Beginning ossification within the coracoid is evident at three years.

In order to avoid errors of interpretation in roentgenograms of the shoulder one must take several views.

Ossification within the epiphysis of the acromion is rarely evident before the middle of the fourteenth year.

Complete ossification of the acromion epiphysis takes place about the middle of the eighteenth year.

Complete ossification within the upper epiphysis is evident about the nineteenth year.

There is no trace of the epiphyseal line at the twentieth year.

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SOME OBSERVATIONS ON THE TREATMENT OF HYPERTHYROIDISM WITH X-RAYS*

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IN 1919, we reported in the *Journal of the American Medical Association* the results of our observations on 262 cases of hyperthyroidism treated with *x*-rays, and reviewed the literature up to that year. Since that time, we have had an opportunity to observe 107 additional cases.

In this paper, I shall not attempt a statistical study of the cases seen, but will present to you the observations we have made in studying this rather large group of cases, with a description of the methods employed and the results obtained.

The successful treatment of hyperthyroidism requires the best possible cooperation of the clinician, surgeon and roentgenologist. To accomplish this at the Massachusetts General Hospital, we have established a goiter commission consisting of an internist, surgeon and roentgenologist. This committee meets once a week, and all patients are seen by the members in consultation. If the patient is a new one, an attempt is made to make a definite diagnosis of the type of disease present, and the form of treatment agreed upon. Old cases are reexamined before changing the form of treatment, also for observation and discharge. Metabolism tests are made before, after and during treatment. Sources of infection, such as diseased teeth, tonsils, etc. are looked for, and, if found, proper treatment is instituted. The condition of the heart is observed, and, in women, the pelvic organs are examined. The presence or absence of an enlarged thymus gland is determined, when possible. The patient's occupation, home life and the distance of residence from the clinic are considered.

A photograph of the patient is made and the pulse rate, weight, temperature and metabolism rate are charted.

In determining the form of treatment to be instituted in each individual case, we consider:

1. The type of disease present.
2. The environment and distance of residence.

We have found the following grouping fairly satisfactory for this purpose:

Colloidal, cystic and simple goiters.
Malignant goiters.
Toxic adenomata.
Non-toxic adenomata.
Exophthalmic goiters.

Colloidal, cystic and simple goiters should never be subjected to roentgenization. If they cause pressure symptoms, or, if for other reasons it is advisable to remove them, surgery is advised.

In malignant goiter, we advise immediate operation followed by postoperative raying. If, for any reason, surgery is contraindicated, roentgenization alone may bring about a temporary cure. A patient of this type came under my observation in 1916, three years after she had been operated upon. At the time of this observation, she had extensive recurrence with metastases in the lungs.

Under roentgenization, these signs disappeared, and she was free from symptoms until death of intercurrent disease in 1921.

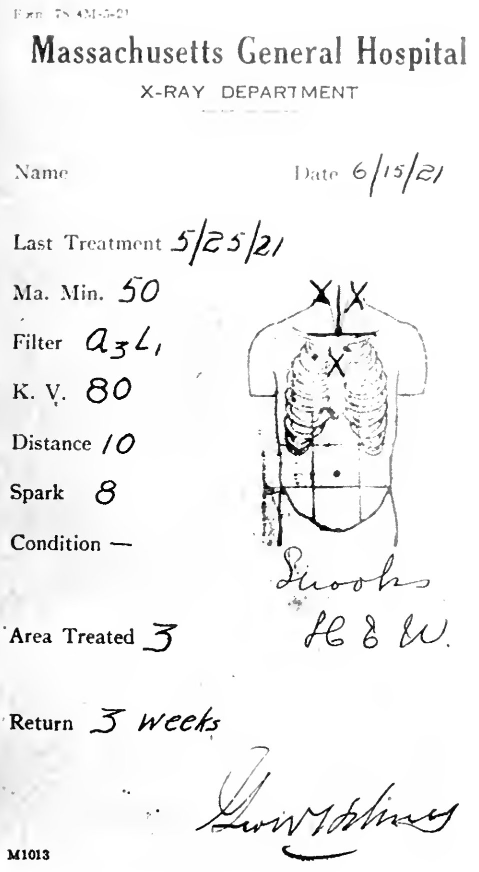
Toxic adenomata respond readily to *x*-ray treatment, but surgery is quicker, and, as the surgical risk is slight, most of these cases are referred for operation.

We have never treated a non-toxic adenoma, though I see no reason why localized nodules could not be reduced by exposure to radiation. As a rule, these cases are kept under observation or treated surgically.

Exophthalmic goiters are usually started on rest and radiation. It has been our experience that the surgical risk is considerably greater in this class of cases, and that they respond very well to roentgenotherapy.

The importance of rest increases with the toxicity of the case, and those having a very high metabolism are usually given some rest before instituting *x*-ray treatment. Even in

*Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D.C., Sept. 27-30, 1921.


Massachusetts General Hospital
X-RAY DEPARTMENT

Name Date 6/15/21

Last Treatment 5/25/21

Ma. Min. 50

Filter a3L1

K. V. 80

Distance 10

Spark 8

Condition —

Area Treated 3

Return 3 weeks

M1013

FIG. 1. A prescription for treatment.

clinics where surgery is used exclusively, this type of case would be given a rather long period of rest, and we believe rest, combined with *x*-ray treatment, gets the patient in much better condition for operation and reduces the operative risk by destruction of the thymus, and, if not too much prolonged, does not make the operation more difficult. As a matter of fact, a large percentage of cases so treated never come to operation.

The following cases are illustrative of the types treated and the results obtained:

CASE I. Exopthalmic goiter of long duration in a woman, aged forty-one. Toxic symptoms were marked for four years. There was a symmetrical marked enlargement of the thyroid with exophthalmos and emaciation. Systolic bruit was present. The accompanying chart shows the course of the disease under treatment.

Treatment was started in March, 1918. At that time, the patient's metabolism was 85 per cent above normal, pulse rate 120, and weight 52 kgm. Three weeks later, a second treatment was given, at which time there was no marked change in her condition. In nine months, she had received six treatments, during which time there was a steady rise in weight and drop in the pulse rate and metabolism. She was given two more treatments in April and May, 1919, making ten treatments in all, covering a period of one year. The metabolism rate was slightly elevated until the latter part of 1919 when it reached normal, and it has remained so since. Her last metabolism observation was in December, 1920. Since that time, she has been under general observation and apparently is entirely well.

This case seems to represent a cure by *x*-ray treatment of a long-standing severe type of exophthalmic goiter. The period of time dating from the initial treatment, before metabolism reached normal (practically two years), would probably have been shortened considerably had surgery been used. But on the other hand, the patient was an extremely poor surgical risk, and her present condition is in every way satisfactory. It is also probable that the periods between treatments were longer than necessary, and that somewhat heavier dosage might have been used.

CASE II. Exophthalmic goiter, a rather mild early case in a man aged forty-two. Toxic symptoms present for six months.

At the time of his first treatment in April, 1920, he had lost 20 lbs. in weight during the preceding six months. There was sweating of the hands, palpitation, dypsnea, slight enlargement of the thyroid and exophthalmos. His basal metabolism was 40 per cent above normal, his pulse rate 95 and his weight 40 kgm.

He was given one *x*-ray treatment in April, another in May, and in June a second metabolism test was made, at which time there was a drop to 10 per cent above normal, and a rise in weight to 46 kgm. Three more *x*-ray treatments were given, the last in August, 1920, four months after beginning treatment. His last metabolism observation was made in June 1921. It was practically normal. His pulse rate at that time

FIG. 2. CASE I before treatment.

FIG. 3. CASE I after treatment.

was 72 and his weight had reached 52 kgm. and he was practically free from symptoms. He is a tailor by trade, and at no time did he stop work.

This case illustrates the prompt response to treatment of a mild early case, a cure being brought about in the short period of four months without interfering with the patient's mode of living or occupation. He has been under observation now for over a year and has remained well.

CASE III. Toxic goiter of moderate severity, of rather long duration (five years), in a woman, aged forty. No eye signs and no

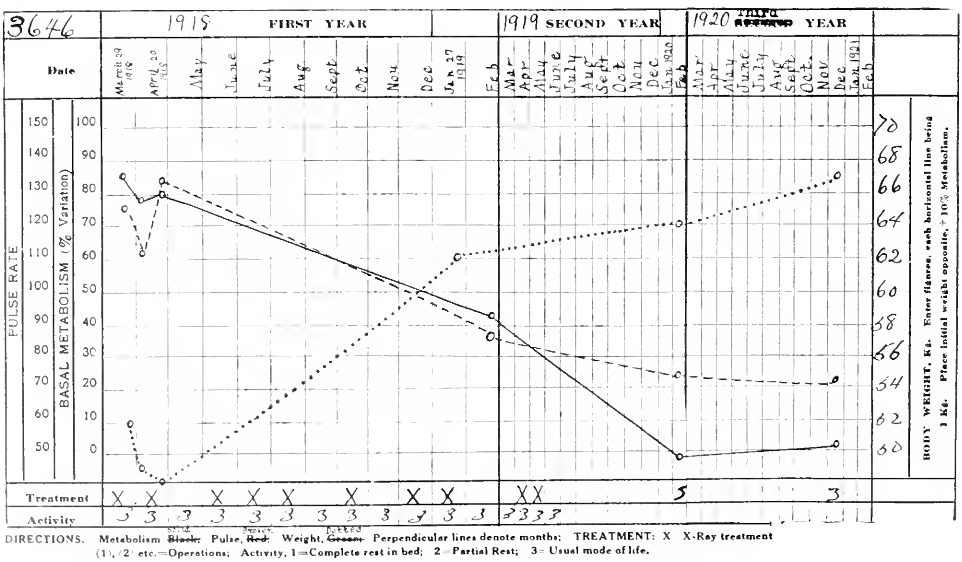


FIG. 4. CASE I. Chart showing the results of x-ray treatment in a case of exophthalmic goiter of long standing.

FIG. 5. CASE II before treatment.

FIG. 6. CASE II after treatment.

evidence of localized adenomata, and definitely worse during the year preceding treatment. The goiter committee advised rest and x-ray treatment followed by surgery if necessary.

When the patient was first seen on September 24th, 1920, her metabolism was 49 per cent, her pulse rate 100, and her weight 45 kgm. She was given an x-ray treatment and complete rest in bed. At the end of a month, a second treatment was given. At this time, there was a slight drop in the

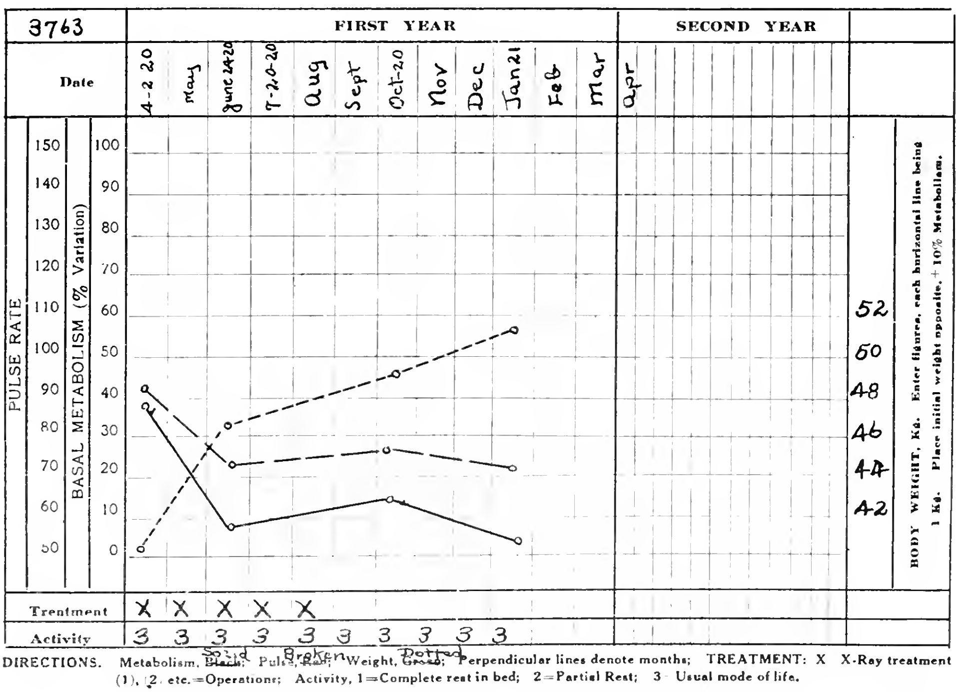


FIG. 7. CASE II. Chart showing results in a rather mild early case of exophthalmic goiter.

FIG. 8. CASE III before treatment

FIG. 9. CASE III after treatment.

pulse rate and metabolism, but no gain in weight. Between October, 1920, and April, 1921, she received nine treatments, making eleven treatments in all. At this time, her weight had reached 57 kgm., her pulse rate, 90, and her metabolism 10 per cent above normal. The last observation was made in August, 1921, at which time her weight had

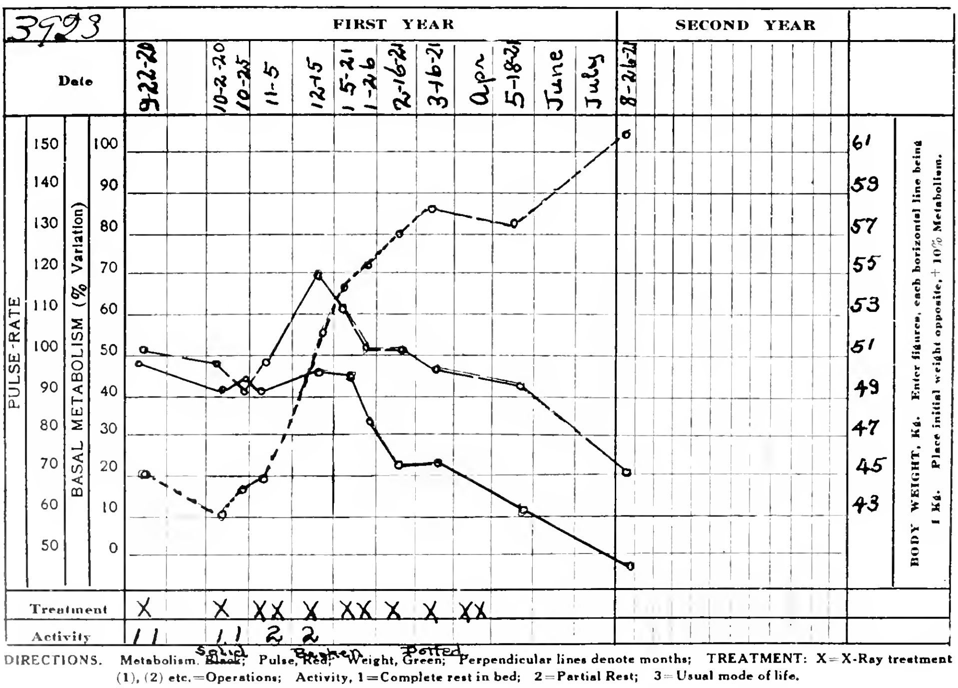


FIG. 10. CASE III. Chart showing the results in a case of toxic adenoma.

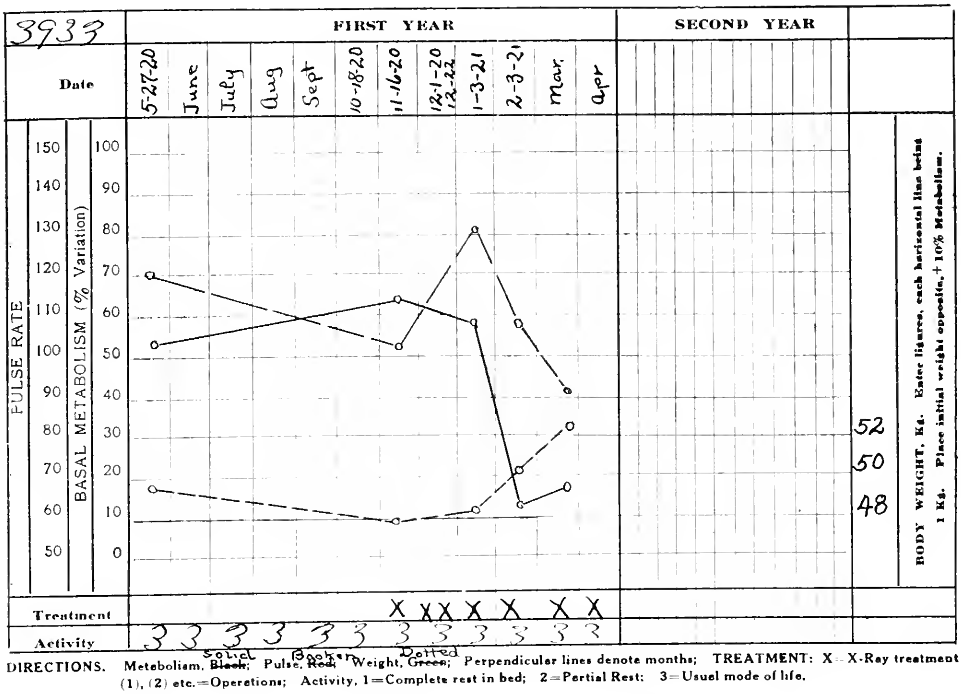


FIG. 11. Chart of the results in Case IV.

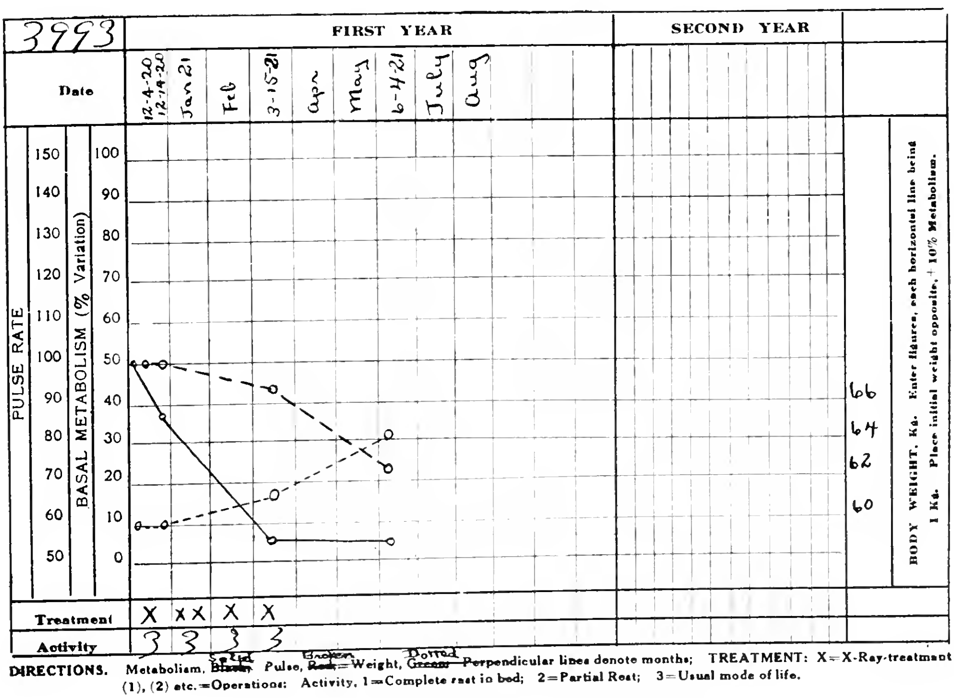


FIG. 12. Chart showing the results in Case V.

reached 61 kgm., the pulse rate, 70, and her metabolism slightly below normal.

This case was probably a rather long-standing toxic adenomata. Her treatments were given at a 16-inch target skin distance, using one field of entry covering the thymus and thyroid region, supplemented by complete rest for the first two months and partial rest for three more.

At the present time, this patient is entirely free from the toxic symptoms. The very rapid gain in weight, with low metabolism, may mean the beginning of hyperthyroidism. I believe that the treatment should have been stopped sooner.

Case IV. An adenoma of long duration in a woman, aged forty-one.

When the patient was first seen in April, 1920, toxic symptoms had been present for only a few weeks, but there was a history of enlargement of the thyroid for twenty-four years. She had had some medical treatment. She was suffering from nervousness, irritability, occasional attacks of diarrhea, palpitation and loss of weight. Her metabolism was +54 per cent, her pulse rate 120, and weight 49 kgm.

X-ray treatment was advised. The patient did not return for treatment, however, until the following November, seven months after the first observation. She had had no treatment during that time. There had been a slight drop in the pulse rate and some loss of weight. The metabolism was + 64 per cent. In general, her condition was about the same. Between November and January, she received four *x*-ray treatments. A metabolism test made at that time showed 59 per cent above normal. Her pulse rate and weight were practically unchanged. Three more treatments were given, and a metabolism observation in March showed a very definite drop to 12 per cent above normal. Her weight had reached 52 kgm. and her pulse rate was 90. The last observation on this patient was made on June 28, 1921. She had been working unusually hard during the spring. She complained of occasional attacks of palpitation, but was free otherwise from symptoms.

This case is of interest because of the rather long period in which she was under observation before starting treatment, and the absence of any improvement until treatment was given,—seven months' observation without treatment and no change in condition; four months under treatment and practically complete disappearance of symptoms.

Case V. Exophthalmic goiter (postoperative) in a woman, aged forty-four. The toxic symptoms were of eight years' duration. In 1913, a partial thyroidectomy was done.

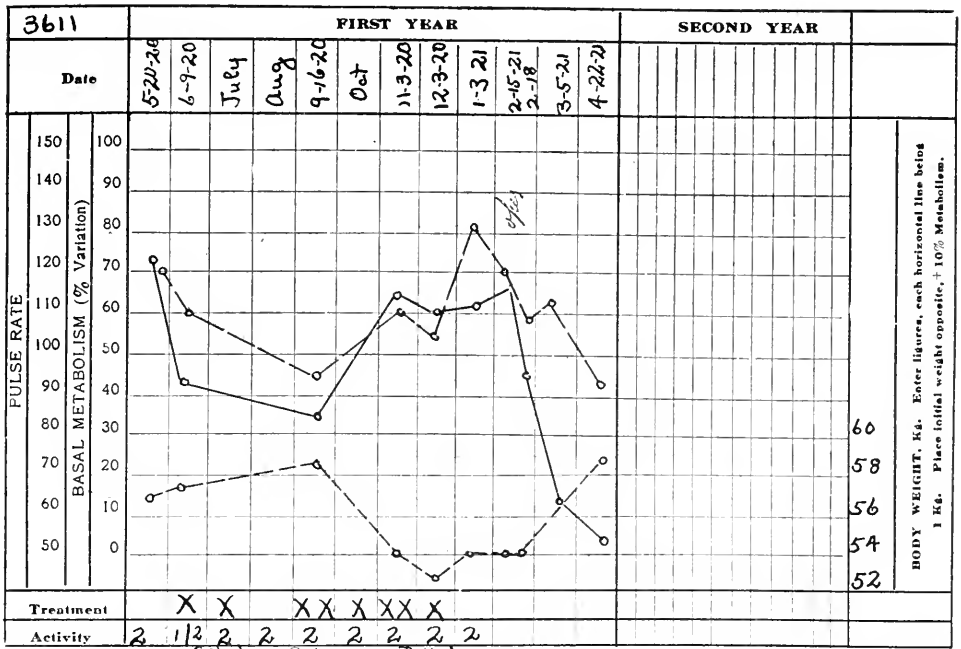
When first seen in December, 1920, patient complained of nervousness, irritability, dyspnea, palpitation and loss of weight. The heart was considerably enlarged and edema of the feet was present. There was well-marked fullness over both lobes of the thyroid, and the scar of the old operation was present. The tumor was vascular and fairly soft. Her metabolism was +50 per cent, pulse rate 100, and weight 60 kgm. She was given five *x*-ray treatments between December and March, at which time a second metabolism test was made and the rate found to be normal. There had been a slight gain in weight and a slight drop in pulse rate. In June, 1921, her weight had reached 64 kgm., her pulse rate had dropped to 72 and her metabolism remained normal. There was no marked decrease in the size of the goiter, but she was free practically from symptoms of hyperthyroidism, and her cardiac condition was much improved.

This case represents an incomplete surgical cure, of long duration, with a badly damaged heart. Under *x*-ray treatment, the cure was completed in a period of three months.

Case VI. A rather severe acute exophthalmic goiter in a woman, aged thirty-two.

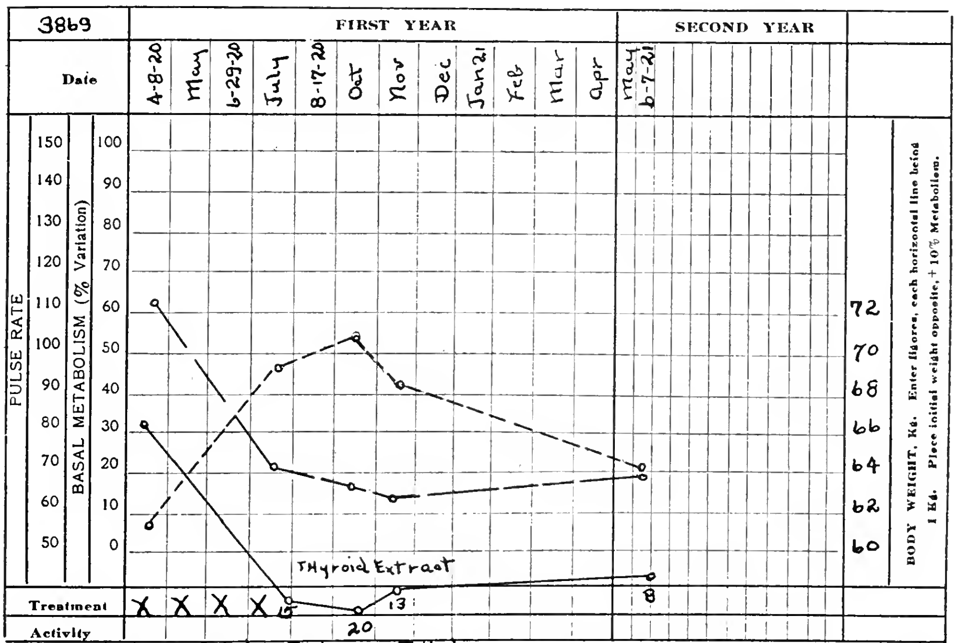
When patient was first seen in April, 1920, she was suffering from nervousness, irritability, sweating, dyspnea, palpitation, increased appetite and loss of weight. She was also emaciated. There was a moderate symmetrical enlargement of the thyroid. Exophthalmos was present. Her metabolism was +72 per cent, her pulse rate 120, and her weight 36 kgm.

Rest and *x*-ray treatment were advised. The patient was unable to carry out this program, and only partial rest was obtained. After receiving four treatments, her metabolism had dropped to +35, the pulse rate to 95 and the weight had increased 2 kgm. Treatments were continued, four more be-



DIRECTIONS. Metabolism, Black; Pulse, Red; Weight, Green; Perpendicular lines denote months; TREATMENT: X=X-Ray treatment (1), (2) etc.=Operations; Activity, 1=Complete rest in bed; 2=Partial Rest; 3=Usual mode of life.

FIG. 13. Chart showing the result in Case VI.



DIRECTIONS. Metabolism, Black; Pulse, Red; Weight, Green; Perpendicular lines denote months; TREATMENT: X=X-Ray treatment (1), (2) etc.=Operations; Activity, 1=Complete rest in bed; 2=Partial Rest; 3=Usual mode of life.

FIG. 14. Chart showing the course of the disease in Case VII.

ing given. In December, after a period of seven months, she had received eight treatments. Her metabolism had returned to 60 above normal, her pulse rate was over 100 and her weight had dropped to 54 kgm. As she was not doing well, she was seen in consultation, and surgery was advised. Ligation, followed by a hemithyroidectomy, was done. She was seen last on April 4, 1921, at which time her metabolism had dropped to normal. Her pulse rate was 90 and her weight 58 kgm.

This case is one of a small group which has failed to respond to x-ray treatment in a reasonable length of time and in which we have resorted to surgery. A comparison of this case with those which respond well does not reveal any striking difference in the symptoms or history of the disease. It may be that the failure is due to error in technique.

Case VII. An early typical case of exophthalmic goiter of a rather mild grade, in a woman, aged thirty-six.

When she was first seen in April, 1920; she had had toxic symptoms for five months, and a noticeable goiter for six months. She complained of nervousness, irritability, palpitation, sweating and loss of weight. The thyroid was soft, symmetrical and slightly enlarged. A faint bruit was present, and also considerable exophthalmos. Her metabolism was 30 per cent above normal, the pulse rate, 110, and her weight, 65 kgm.

X-ray treatment was advised. There was no change in the patient's mode of living.. Treatment was given at an 8-inch distance, using three portals of entry. By this time her metabolism had dropped to 10 per cent below normal, her pulse rate was 70, and her weight had reached 69 kgm. She showed definite signs of hyperthyroidism. X-ray treatment was stopped, and she was placed on thyroid extract. In November, her metabolism was still slightly below normal. The thyroid extract was continued until March, 1921. From an observation made the following June, three months after discontinuing the thyroid tablets, her weight was 64 kgm. pulse rate, 70, and metabolism slightly below normal. At this time, she showed practically no signs of myxedoma or of hyperthyroidism. This patient received only four treatments given in the routine manner, in a period of less than four months, and changed from a state of mild hyperthyroidism to mild myxedema. This condition was apparently temporary, however, as she is now getting along very well without thyroid extract.

This case is especially interesting, as it seems to show that the x-ray may bring about a temporary inhibition of thyroid function.

Case VIII. A moderately severe case of hyperthyroidism, apparently adenomatous, in a woman, aged thirty-eight. The goiter and toxic symptoms were of one year's duration.

When the patient was first seen in October, 1919, she complained of nervousness, irritability, dyspnea and loss of weight. The goiter was small and firm, with a loud bruit. There was no exopthalmos. Her metabolism was 50 per cent above normal, her pulse rate 115, and her weight 39 kilograms.

She was started on x-ray treatment and no change was made in her manner of living. After three treatments were given, there was a slight gain in weight and a drop in the pulse rate. No definite change in the metabolism rate was noted, however, but, after six treatments, covering a period of four months, her metabolism dropped to 8 per cent above normal, her pulse rate to 90, and her weight had reached 49 kgm. One more treatment was given and she was requested to return for observation in six months. This observation was made in September, 1920, at which time her weight, pulse rate and metabolism were practically normal. She was seen again in Febraury, 1921, and all the findings were approximately the same, but in July, 1921, when she reappeared for examination, her metabolism had dropped well below normal, her pulse rate was only 50 and her weight unchanged. Her skin was dry and she showed definite signs of myxedema.

The interesting feature in this case is the development of myxedema nearly two years after the last x-ray treatment, and after the patient had been well for a period of over one year. It is possible that the results in this case are due to the development and contraction of fibrous tissue causing interference with the function of gland, or she may be one of those cases of hyperthyroidism

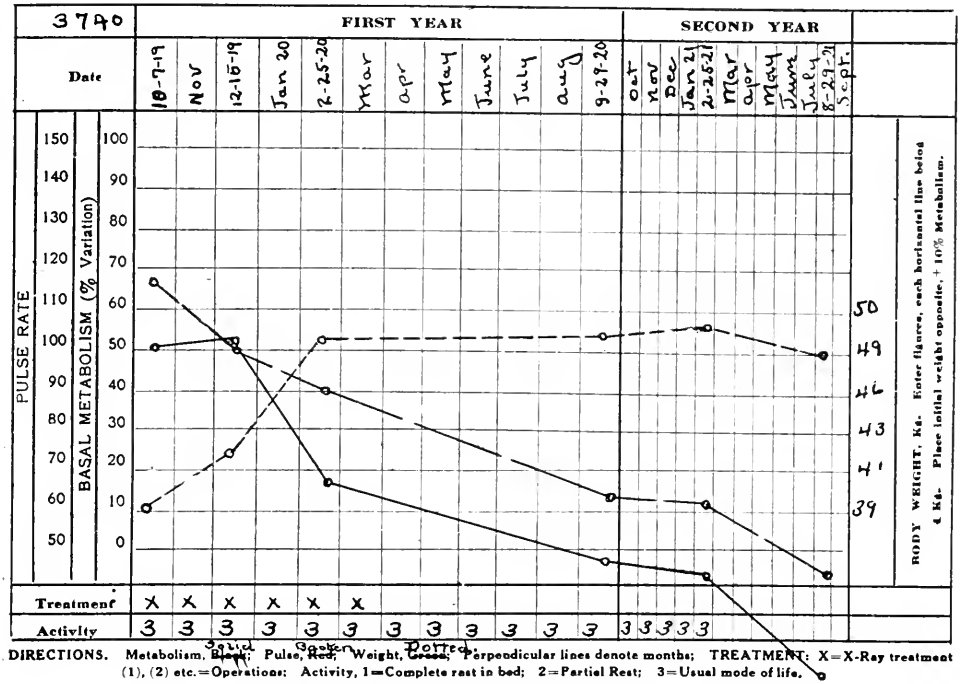


FIG. 15. Chart showing the course of the disease in Case VIII.

which develop late myxedema regardless of treatment.

TECHNIQUE

In the light of our present knowledge, it is fair to assume that the following physiological and histological processes take place when the thyroid gland is subject to radiation.

The function of the cells composing the glandular structures is inhibited. As the dose is increased these cells atrophy and disappear, to be replaced by connective tissue, and, after a lapse of considerable time, where heavy raying has been given, it is possible that the contraction of this new fibrous tissue may interfere with the blood supply to such an extent as further to inhibit glandular function. The dose, therefore, should be adapted to the type of case under treatment, and must of necessity, be within the limits of skin tolerance. In mild cases, with little or no thyroid enlargement, a dose sufficient to inhibit glandular function repeated at intervals may be all that is required to bring about a cure. In more severe cases, with larger glands, heavier radiation (given at more frequent intervals so that there will be not only inhibition but cell atrophy) is probably necessary. In these cases, however, the dose should not be too large, nor the treatment too prolonged, otherwise the destruction of the gland, or the late results of connective tissue contraction, may be so great as to bring about a complete loss of function, with resulting myxedema. In very severe cases, it may be justifiable to give as large a dose as the skin will tolerate, even producing a slight erythema, and not guarding particularly against the complete destruction of the gland.

As already stated, the dosage will vary with the type of case. We have employed a 4 mm. aluminum filter with 8 inch parallel spark gap between points. An 8 inch target skin distance was used in our early cases. Lately we have used a 10 inch, and, in some cases, a 16 inch distance. In this way, the amount of radiation reaching the gland in proportion to that received by the skin is increased. In most of the cases, three exposure areas have been used, one on each side of the neck, and one over the thymus region. In some cases, where a 16 inch distance was used, we have given one single exposure in front over the midline including the entire thyroid and upper thymus region.

In a small group of cases, five areas of ex-

posure were used, one over each side of the neck, one over the thymus region and two over the back of the neck. No definite advantage was noted in this method of exposure. The time interval between treatments has been usually three weeks. In some we have shortened it to two weeks. I believe that it is a safer procedure when one wants to get the maximum effect, short of an erythema, to diminish the time, rather than to increase the dosage.

Basal metabolism tests are done frequently during the early part of the treatment, and, as improvement takes place, less frequent observations are made. The findings are recorded on a chart along with a record of the pulse rate and weight. This chart occupies the same relation to the treatment of hyperthyroidism as the temperature chart in the treatment of fevers. When the basal metabolism reaches normal, treatment is stopped, and sooner, if the drop has been rapid.

RESULTS TO BE EXPECTED IN THE TREATMENT

In cases which respond favorably to treatment, an improvement in the nervous symptoms is usually noted at the end of the first three weeks' interval. At the end of six weeks there should be a definite drop in the pulse rate and in the metabolism, but in many cases the response is more gradual. The metabolism and the pulse rate usually return to normal after six or seven treatments have been given, and in a period of from four to six months. There is usually a gradual increase in weight, the goiter disappears, and the exophthalmos, when present, is relieved and may disappear entirely. Frequently a severe toxic case is able to return to work after the third treatment and from that time on, his treatment need not interfere greatly with his routine life. In cases which are more stubborn, rest should be insisted upon, or surgery resorted to after the fourth or fifth treatment. It is not desirable to prolong the treatment in cases which are not responding well, as the operation will be made more difficult. Four or five treatments given within a period of six months have not in our experience done this. On the other hand, cases which have received a larger number of treatments over periods of from one to two years have been distinctly more difficult at operation. There is, of course, a definite possibility of damage to the skin, such as atrophy and telangiectasia. These results apparently can be avoided by keeping well below the erythema dose. When they happen, they are more disfiguring than the usual surgical scar. The longer time required to bring about a disappearance of the toxic symptoms by *x*-rays may be used as an argument in favor of surgery. This increased interval may increase the damage already done to the heart. On the other hand, one may argue that the amount of damage caused by the stress of operation would be more than that likely to take place in an interval of three or four months during which there was a steady drop in the amount of toxemias present. Myxodema may be brought about by too heavy or too prolonged radiation. It is also possible that this condition may develop several years after radiation as the result of contracting connective tissue, Any observation along this line, must of course, be indefinite, because of the fact that cases of hyperthyroidism frequently become myxedematous under all forms of treatment, and even when no treatment is given.

INTENSIVE X-RAY THERAPY AS SEEN PRACTICED IN THE CLINICS IN EUROPE*

By SAMUEL STERN, M.D.

Radiotherapist to Mount Sinai Hospital.

NEW YORK CITY

THE subject of intensive roentgenotherapy as practiced in Germany and in other foreign countries at present, has been the source of a great deal of interest to the American roentgenologist. Having returned but recently from a visit to the various clinics in Germany, I thought a résumé of my impressions might be of value in helping to clear the atmosphere of some of the confusion in which this subject seems to be enveloped at present. I have found that there seems to be a unanimity of opinion on but two of the essentials in carrying out intensive *x*-ray therapy:

1. The necessity of having apparatus that is able to deliver at least 200,000 volts.
2. The essential employment of heavy filters.

On all other, even the most important and vital questions of technique, there is the greatest divergence of opinion. Each man firmly believes that his method is superior to the others, and can usually give an apparently logical reason for this belief. I think this clearly shows that the really essential factors are the deliverance of heavily filtered, highly penetrating rays to the parts treated, and that all the other details on which we lay so much stress are of secondary consideration. The technique briefly described, as I have seen it used at the various clinics, is as follows.

FRANKFORT FRAUEN CLINIC

(Profs. Opitz and Walter Friedrich)

Distance	*Size of fields*	*Time*	*Filter*	*S. G.*	*ma.*
50 cm.	25 x 25	6 to 7 hrs.	1 c. mm.	38 cm.	2½

Mammary carcinoma. 1 large field.

Uterine Carcinoma. 2 fields, front and back.

The treatment is not repeated, surely not within six months of its administration.

Myoma

Distance	*Size of fields*	*Time*	*Filter*	*S. G.*	*ma.*
30 cm. with compression	16 x 16	4 to 5 hrs.	1 c. mm.	38	2

In large myomas, the distance used is 50 cm. and the rest of the formula is similar to that of carcinoma, except the time is shorter. The method of measuring is with a specially devised iontoquantimeter perfected by Professor Friedrich. This instrument enables him to measure the exact dosage administered, irrespective of filter, penetration, distance or any other detail.

One hundred and seventy electrostatic skin units make an erythema dose. This can be kept track of without stopping the apparatus even for an instant, and when this number is reached, he feels certain that the patient has received the exact dosage intended to be given. He has been using this apparatus for the past two years, and claims that it is absolutely reliable and can always be depended upon. He considers that the question of *x*-ray measurement is solved. I found him to be one of the most brilliant physicists I have met, and I feel that we cannot lay too much stress upon any statement that he may make. The apparatus, very superficially described, consists of a small (1 c. cm. capacity) ionization chamber made of aluminum, which is connected with a rubber tubing to a large ionization chamber fitted with a gold leaf electroscope. This is charged, and as the rays strike the small ionization chamber, it is gradually discharged and the time carefully noted. Each apparatus is tested to determine how many electrostatic units each discharge represents. These are carefully added up, and, when the required total is

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reached, treatment is stopped. There are some inaccuracies due to the self discharge of the electroscopes, which must be taken care of. This is done by charging the electroscope to 6 and then waiting to see how much it will discharge of its own accord, during the time that it took for one complete discharge with the ray in operation. We now determine how long it takes to discharge this number of units with the ray, and then multiply this time with the number of times the electroscope has been discharged during the treatment. This amount of ray is added to complete the dosage. All this sounds rather complicated, but is really very simple. The small ionization chamber can be left on the skin during this treatment to measure skin dosage, or it can be inserted into the rectum or vagina, to measure depth dosage. The carcinoma dose as measured in the vagina is 152 electrostatic units. The myoma dose is 100 to 120 skin units to each field, or 80 units measured in the vagina. In making measurements in the vagina, a permanent horse hoof catheter is kept in the bladder to keep this organ empty.

FREIBURG DEPARTMENT OF INTERNAL MEDICINE

(Profs. De la Camp and Kupferle)

Malignancy

Distance	*Size of fields*	*Time*	*Filter*	*S. G.*	*ma.*
30 cm.	10 x 10	1 hr.	1½ c. mm.	180 to 200 kv.	2

This dose is administered every eight days until the patient has had four treatments; then it is repeated in six to eight weeks.

Tuberculosis of the Lungs. Cases must be selected very carefully. No tertiary cases are treated. The affected area is divided into three fields: anterior, lateral and posterior. Each field is treated as follows:

Distance	*Size of fields*	*Time*	*Filter*	*S. G.*	*ma.*
30 cm.	Small	8 to 10 m.	1 c. mm.	170 kv.	2

Treatments are given every eight days until each field receives three treatments, then they are discontinued for many months.

The treatment of tuberculous adenitis is the same as above, except that the time is fifteen minutes. It is repeated every eight days or two weeks.

Basedow's Disease. The thyroid and thymus region is divided into four fields, two supra- and two infraclavicular. One field is treated twice a week, so that each field receives a treatment every two weeks. The technique used is the same as that in tuberculosis, except that the time is from twenty-five to thirty minutes. The series is repeated three or four times, followed by a long wait.

FREIBURG SURGICAL CLINIC

(Prof. Lexar and Dr. Kohler)

Malignancy

Distance	*Size of fields*	*Time*	*Filter*	*S. G.*	*ma.*
50 cm.	Large	3 hrs.	0.75 zinc	200	2

The dose is repeated every four weeks until the patient has had four or five treatments.

Fractures. For the past year and a half they have been treating fresh fractures, with so-called irritating doses, with most satisfactory results. They have succeeded in reducing the healing time to about one half. Usually only one treatment is given, as shortly as possible after the fracture has been set. The dose given is about 1 / 10 of an erythema dose.

Distance	*Time*	*Filter*	*S. G.*	*ma.*
30 cm.	10 m.	½ c. mm.	180 kv.	2

In small bones only one field is treated, larger bones are treated anteriorly and posteriorly, but with reduced time.

Tuberculous bones and joints are treated once in three weeks, with even smaller irritating doses—1 / 20 to 1 / 30 of an erythema dose, that is, about one to four minutes, using the above formula.

To take advantage of the use of scattered rays, in the treatment of small bones, the field is enlarged by wrapping them in wet towels.

Late Rachitis. They found marked benefit in the treatment of these cases by exposing both temporal regions. Two treatments are given at four to six week intervals, using

about 1 / 3 of an erythema dose, with 0.5 zinc filter.

Prophylactic Treatments. These are given very much like the treatments for existing malignancy—every four weeks until five treatments are given in succession, then discontinued for six months, after which period three more treatments are given.

To avoid constitutional disturbances, during and following the treatments, they are using Uzara tablets with very satisfactory results. Two tablets are given about half an hour before the treatments. This dose may be repeated at any time as the drug is quite harmless.

FRANKFORT FRAUEN CLINIC
(Prof. Seitz.)

Mammary Carcinoma. The affected side is divided into three fields: a large field at a distance of 80 to 90 cm., taking in the entire breast region; a small field at 30 cm. distance over the supraclavicular space, and another small field at 30 cm. distance over the axilla. A full erythema dose is given to each field, using a 0.5 zinc filter and a 40 cm. spark gap. This is repeated in six weeks and again eight weeks later, if necessary.

Uterine carcinoma. These are treated in three series: Series I. Three fields in front and three fields in back at 23 cm. distance with compression, and one field over the vulva without the use of a speculum. Series II is given six weeks later over the affected uterine region, three fields in front and three fields in back. Series III is given eight weeks later over the parametrium. They also use 100 mgm. of radium with a 0.5 Cu filter, left in place from eighteen to twenty-four hours.

Myomas. These are treated through four fields: anterior, right and left at 23 cm. distance with compression, and the same posteriorly. They use 0.5 zinc filter, 40 cm. spark gap, and 2.2 ma. Under these conditions an erythema dose is given in about thirty-eight minutes, depending on the tube used. In large myomas, a fifth field is taken from above anteriorly.

They find that measured at 10 cm. depth, the ovarian dose is 30 to 40 per cent; the sarcoma dose is 60 to 70 per cent; and the carcinoma dose is 110 to 120 per cent.

In Frankfort I also visited the institute in charge of Prof. Friederich Dessauer. Here they have been doing some extremely valuable work in connection with the physics of *x*-ray therapy. Some of his work is of great value in determining the amount of dosage necessary in deep *x*-ray applications. After two years of experimenting, Prof. Dessauer has completed a set of charts, showing ray absorption at different depths, applied with filters of various thickness, at different distances, with the tube charged with varying kilovoltage. By taking measurements of the distance at which the affected parts are situated, and transferring these measurements to these charts, one can readily work out the necessary dosage that must be applied to each area to give the required depth dose. These charts show conclusively what an important role the scattered rays play in *x*-ray application. I do not think we ever realized how much ray the protected parts received, a great deal more than we ever suspected.

At the clinic of Prof. Wintz at Erlangen, for carcinoma of the uterus they use four fields from the front, 6 x 8, and three fields from the back, distance 23 cm. with compression, filter 0.5 Cu with the Suderöhre and 0.5 Cu + 4 mm. aluminum with the Coolidge tube, spark gap 40 cm. and 2 ma. Exposure varies from thirty-eight to forty-five minutes. Six weeks later they treat three fields in front and three fields in back over the affected parametrium. Eight weeks later the same treatment is given over the other parametrium. They reckon on getting about 18 per cent at a depth of 10 cm. Instead of radium locally, they use a 0.5 solution of Cu selenium applied with the galvanic current in the form of cataphoresis. When patients receive a full erythema dose they always have a slight erythema the day following the treatment. Three or four days later the small hair papillae become raised and more reddened, a condition they call erythema papillaries. This they claim is constant. Five or six weeks later this is followed by an even pigmentation.

About the third or fourth week after the treatment the patient is usually given intravenously 1 c. cm. of serum and 20 c. cm. of normal saline solution.

Myoma. Small myomas are treated through two fields in front and two fields in

back at 23 cm. with compression. Large myomas receive four fields in front, two lower, 8 x 8 at 23 cm. and two upper 10 x 15, at 30 cm. distance, the same posteriorly.

Sarcoma of the Uterus. In their opinion, no sarcoma of any kind should ever be operated on. The results are good, providing there has been no surgical interference. They put the sarcoma dose at 80 per cent. The technique is the same as that for carcinoma.

Rectal carcinomas are divided into three classes:

1. Those that are situated 8 to 10 cm. distance up the rectum. They are the most favorable and are treated the same as carcinoma of the uterus.

2. Those that are situated 3 to 8 cm. up the rectum. The results are not so good, as it is very difficult to get the required percentage of depth dose to the lesion. They are treated through four fields.

3. Those situated at the anus. Prognosis in these cases is very bad. They are treated through one large field at a distance of one meter, two ingunial fields, and two additional fields from above, directing the ray downwards.

Carcinoma of the Vulva. This is treated at 1 meter distance to the lesion and two inguinal fields at 30 cm.

Carcinoma of the Bladder. The bladder is filled with normal saline solution and small fields, from right and left at 23 cm. with compression, are used. Then the bladder is emptied and one large field in the center at 70 cm. is exposed. This is repeated after six weeks and again eight weeks later.

I am not going into any details about the treatment of non-malignant conditions at this clinic. The technique is very similar, except that not more than ⅔ of an erythema dose is given.

At the Cancer Research Institute at Berlin, Prof. Blumenthal and Dr. Halberstadt, to supplement the effect of *x*-rays, inject intravenously an iodine preparation known as Alival. In treating *mammary carcinoma* they make it a rule to accept no cachetic patients, nor those with pleural or thoracic involvement. They take three fields, if possible, 8 x 10, otherwise one large field from the front, three fields for the axilla, and the supraclavicular space front and back. They use a distance of 30 cm., 0.5 Cu filter, 180 kv., and 2½ ma., and the time required is approximately fifty minutes. They expect to get a decided erythema each time. Treatment is repeated four weeks after the reaction has disappeared. In cases where the arm cannot be raised to apply the ray properly, they insert radium into the axilla.

At the Frauen Clinic in Berlin, Prof. Bumm and Prof. Warnekros use large fields. In uterine carcinoma they take a far field from the front and back, and smaller nearer fields from the sides.

At the clinic of Prof. Franz, the treatment used is very similar.

In the technique used at the various clinics, you can readily see that there is the greatest divergence of opinion even as to the most important details. One insists on large and far fields, to get the benefit of a larger proportion of depth dose and greater amount of scattered rays. The other prefers concentration with compression to get nearer to the lesion. The filters vary from ½ to 1½ mm. Cu or zinc. Some insist on the importance of applying the entire carcinoma dose within twenty-four or forty-eight hours; others divide it over a period of one week. Still others divide it into four weekly doses. The ideas as to what constitutes an erythema dose differ widely. Some are satisfied with the slightest erythema; others insist on a very decided reaction. But the most serious and almost irreconcilable difference of opinion exists upon the question as to when an erythema dose may be repeated. Some clinics say surely not within six months; others repeat it in six weeks, and again at eight weeks, and one clinic applies an erythema dose every month for four or five successive months. This seems almost impossible, but the man who is doing it assured me that, in his opinion, it is a perfectly safe and necessary thing to do. All this leaves us very much confused as to what is really the best technique to follow. Some of the questions decide themselves. For instance, I cannot imagine that any of us would attempt to treat a patient for seven hours a day, for two or more successive days. Nor can I imagine the patient here who would submit to it. This decides the question of divided doses, and also that of filters, as it pretty well excludes the use of 1½ mm. Cu filters. As to the dosage, I think this should depend to a large

extent upon the individual case. We are justified in taking greater chances in cases that are apparently hopeless, and where only the most radical treatment may prove of value. As regards the time when an erythema dose may be repeated, I think this lies somewhere between the two extremes. I would very much hesitate to give four or five erythema doses at monthly intervals, nor would I think it essential to wait six months before repeating it, in case it seemed necessary.

As to the choice of cases, in most of the clinics I visited, I found that they have practically discontinued operating on all cases of carcinoma of the breast and the uterus. They claim that the results with radiation alone are far superior, that they get approximately 85 per cent of cures, including all variety of cases taken at random.

These two classes really make up the largest proportion of cases to which the treatment is best adapted. In malignant growths involving other organs the results are not as satisfactory. They are all very emphatic on the importance of never treating any type of sarcoma surgically, as the chances of metastasis are very much increased by any surgical interference. The non-operated cases usually do very well.

As to benign conditions, I almost think that we can do just as well with our present technique. For instance, the patients treated for a myoma usually menstruate once, twice, or even three times after the treatment. With our present technique, giving them one treatment a week for five or six weeks, they rarely menstruate more than once. The constitutional disturbances are decidedly less severe, and the treatment nowhere near as trying to the patient. The treatment may do well for out of town patients, where time is an important element to consider. Some of the treatments they are using I should be afraid to try. For instance, in leukemia, some clinics take a large field including most of the spleen, and give them 40 per cent of an erythema dose at one treatment. I have seen very marked toxic symptoms following considerably less ray than this. In the *x*-ray treatment of skin diseases I think we do at least as well. I saw them epilate the beard of a patient with a sycosis which took fifty minutes. This epilation here is usually done in eight or nine minutes.

I am not going into the question of apparatus, but I do want to say a few words about the tubes used, as this has a most important relation to the technique to be adopted. At present they are all working with either the Suderöhre, or the Coolidge type of tube, with an occasional Lilienfeld tube here and there. None of them will stand more than 2½ ma. at 200 kv., and are rarely pushed to more than 2-2 ma. For the past two months they have been making tubes of the Coolidge type that will stand a current of 4 ma. But these tubes have not been properly tested out yet as regards their durability. Dr. Coolidge here has perfected a tube that will carry 8 ma. at 200 kv. If this tube will stand the test of time, I consider it one of the most important advances made in this field, and it will put us decidedly ahead as far as tubes are concerned. The time mentioned, as required for an erythema dose at the different clinics, was based upon the use of tubes carrying about 2 ma. With a tube able to stand 8 ma. we can cut the necessary time to one-quarter. This permits us to choose any one of the techniques described.

As regards the future of this "intensive therapy" I do not think there is the slightest doubt that it has come to stay. It is not a fad but is founded on carefully worked out scientfic bases. In fact, I feel quite certain that in time they will be using currents of even higher intensity. In a number of clinics they are even now installing machines that are capable of delivering up to 300 kv. and are merely waiting for tubes that will stand up under this currrent to begin using them. There is no doubt that in some cases of malignancy it shows results that with our present technique are impossible. For instance, I saw a patient in Berlin at the clinic of Prof. Warnekros who was treated four years previously for an inoperable carcinoma of the uterus, involving the fundus, both parametrium, with deep seated pelvic and inguinal glands. On examination I found the uterus freely movable, with no sign of any thickening in any part of the pelvis that I could find. She had gained 50 lbs. since the treatment, and looked the picture of health, a result that with our present technique seems too good to hope for.

THE TREATMENT OF CANCER OF THE RECTUM BY RADIUM*

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In reviewing our work of the past few years in rectal cancer it would be useless to attempt a statistical report, for various reasons. Most of the cases treated have been far advanced in the course of the disease and, while valuable information has been obtained from the radium standpoint, the most that could be hoped for from the patient's side was a certain degree of palliation. The lapse of time over which statistics become of real value has not been great enough. Furthermore, changes in technique have been steadily taking place so that our earlier work represents in no way what we feel we can accomplish at the present time. This is especially true of the past year.

We are stimulated by the surgical results to date to look for another method of treating rectal cancer and our experience with radium encourages us in proceeding along the present lines.

It is true that during the past few years surgical technique has improved and the operative results are consequently better. Even with this, in the hands of the most experienced operators, the results are poor and the operation a very mutilating one. More important than this however is the fact that a large number of patients are inoperable when seen by the surgeon. Statistics are not voluminous on this point but it would seem that over 30 per cent are inoperable in the opinion of the most radical operators when first seen. Rennington[1] quotes from the experience of Tuttle and Lynch over a period of nineteen years that 153 out of 491 cases were inoperable. It is deplorable that so many cases are looked on as hemorrhoids until the disease is far advanced. Lynch[2] found this to be true in 10 per cent of his series, while Rennington[1] quotes Jones as estimating it as high as 75 per cent. In our own experience it would seem that this error was made in well over 50 per cent of all cases. I believe there is no excuse for such errors if the patient's symptoms are considered seriously and a proper examination made.

From an analysis of surgical statistics it appears that the average operative mortality in the best hands ranges from 16 per cent to 20 per cent. Lynch[2] reported 16 per cent in a series of 491 cases. In a series of collected statistics embracing 1665 cases, Hartman[3] found the operative deaths to be 15.8 per cent and from another series Rennington[1] reports 12.5 per cent to 17.5 per cent with improvement in the later years. Hartwell[4] reported 26 per cent in 1905 and Mayo[5] 15.5 per cent in 1912. From a series of 1244 cases by fourteen selected operators Lusk[6] reported a rate of 19.7 per cent. Sepsis accounts for a great deal of this immediate mortality and fortunately it has improved in later years. In his report in 1905 Hartwell[4] placed it at 60 to 70 per cent, and in 1918 Rennington[1] quoted a rate of 39.8 per cent.

In the surgical literature we find considerable use made of the term "cure" as based on a three-year period of observation. I think it would be much better to refer to the result as apparent freedom from disease or "clinical cure" for a fixed period.

Based upon this three-year period of observation Mayo[5] had 33 per cent of operated cases well for 3 years; and 28 per cent over a five-year period. Rennington[1] reported 218 out of a collected series of 966 cases well for three years—about 22 per cent. Hartwell[4] reported 15 to 20 per cent for this period and Grant[7] 16 per cent "permanent recoveries." In his collected series Lusk[6] found 16.7 per cent well for the three-year period. Lusk[6] also quoted Baisch as authority for the fact that from a selected series of cases where careful microscopic examinations had been made, one-third of the cases that were other-

*Read at the Sixth Annual Meeting of The American Radium Society, Boston, June 6-7, 1921.

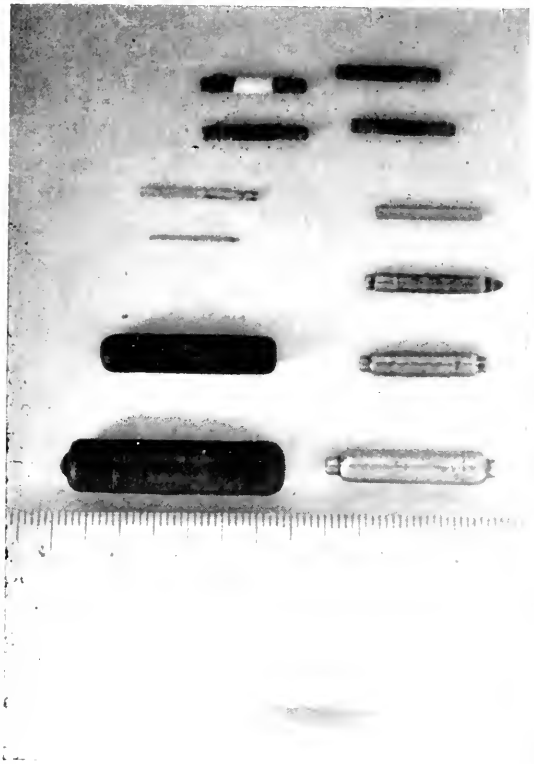

FIG. 1. Showing various tubes, both filtered and unfiltered, used in rectal work.

FIG. 2. Showing double rubber casing, with metal cap to facilitate introduction of annular growths of rectum.

wise operable showed involvement present in the glands.

A fair résumé of these statistics would then give us the following results. At least 30 per cent of cases are inoperable when first seen by the surgeon. Of the operable group the immediate mortality is at best about 16 per cent. The cases found clinically free from disease at the end of three years average below 20 per cent although a few selected groups are reported over 30 per cent.

Granting, therefore, a generous margin of doubt in favor of the surgical procedure we find that in the best hands an average of 14 per cent of all cases coming to the surgeon are free from disease at the end of three years and we know of course that this rate is lowered with each succeeding year.

This procedure entirely leaves out 30 per cent of the cases to begin with, or gives only a colostomy for relief where it is indicated. It brings to an abrupt end about 16 per cent of the operable cases. In the light of Lusk's report on gland involvement a radical procedure is begun in 1 out of 3 cases, which it is useless to attempt to complete. It seems unquestionable that many of the cases are rendered more comfortable for their remaining period of life when we consider the physical and mental shock of such a radical procedure, the suffering from sepsis in many and in many others the discomfort of a rectal stoma that does not function comfortably.

Since nearly all malignant lesions of the rectum are either adenocarcinomas or epidermoid carcinomas we have a certain amount of knowledge of their response to radium from experience with the same types of growths in other parts of the body. The problem is therefore largely one of technique. Unfortunately this is not as simple as it might seem.

In attempting to adapt our technique to the individual case we must have in mind something of what we may reasonably expect to accomplish. A review of our work to date may aid in formulating some such plan.

We have treated in all 161 cases of rectal cancer at the Memorial Hospital during the past four years. Of these practically all were very advanced cases: many hopelessly disseminated, others advanced recurrences. About 40 per cent of the group represent eleventh-hour efforts to try a new remedy, and, as I look back over them, I feel sure they would have been better off had no treatment with radium been given. There comes a time in the course of malignant disease when even the physical agents are of no avail.

A large number of cases have been benefitted from one to three years and then died of distant involvement or some intercurrent disease; others are still improving, and some with a fair hope of complete regression of the disease, providing there is not already distant metastasis. By improvement I mean inhibition of the growth, very frequently decrease in its size, with fibrosis which tends to create a local process rather than an actively growing disseminating one. The decrease in size relieves the partial obstruction; constipation is therefore less marked. Bleeding is largely stopped, discharge of mucous is lessened and pain is very materially decreased. With a certain amount of surface healing and deeper fibrosis the amount of septic absorption is lessened. This results in a gain in weight and strength and a general feeling of well-being otherwise not experienced by the patient. In a few cases the palliative relief has been prolonged over periods of up to three years so that patients are able to go about their daily duties practically symptom free, although we know from periodic examinations that malignant tissue is still present.

Fourteen patients only out of the entire series are now clinically free from disease for periods ranging from four months to four years. Two of these cases were granulomas of the type of lymphosarcomas while the others were typical adenocarcinomas or epidermoid carcinomas. The oldest case now free from disease for about four years has a marked fibrous tissue stenosis due to over-radiation with heavily filtered radium placed within the lumen of the gut. This error we feel we can now safely eliminate by proper protection. Another case treated over a year ago had an annular growth about 6 cm. in diameter of the lower sigmoid; operation was advised against because of a high percentage of blood sugar; and following two treatments with radium he has now been entirely free from any evidence of disease for nearly a year. No stricture is palpable and the patient has no symptoms. The result is of interest because of the complicating diabetes.

A type of case that had been very discouraging to us, until the past year, was the bulky infiltrating growth low down in the rectum and frequently involving the sphincter. Under radiation it appeared to improve for a time and then broke down causing profuse discharge externally and usually with a loss of sphincter control. Five of these cases have been treated with very large doses of both buried emanation and surface radiation followed by local excision two to four weeks later. All 5 cases have remained free from disease now for periods ranging from seven to fourteen months.

During the past year we have been impressed by the number of cases that seemed to improve for a short time and then distant metastases, usually in the liver, became evident. Under such circumstances it is quite evident that the initial discomfort resulting from intense radiation of the local lesion is not warranted if the disease has already become generalized. In view of this we now feel that an exploratory laparotomy is justified in most instances where the local growth presents possibilities of complete regression from the use of radium. In the first place it permits of a complete examination of the growth. If extension has taken place it saves the patient the intense discomfort of an intense local treatment. If the lesion is one which warrants radical treatment with radium it is frequently an advantage to bury emanation into the growth from above, thus insuring a much more accurate application. If a colostomy is indicated and advisable it can be done at that time.

In a number of instances this procedure has saved the patient a great deal of useless radiation. We have been much surprised to find how frequently distant metastases were present with a relatively small primary growth. We have not depended entirely on the presence of enlarged glands to dissuade

us from radical treatment, subsequently, because a certain number of these are inflammatory; but in practically every instance where the glands were definitely involved the liver was also extensively involved. In these cases no radium was used locally. In some, radium and *x*-ray were used externally as a palliative measure.

We have not done a colostomy as a routine procedure. Lynch[2] feels that early colostomy in inoperable cases is as vital as early operation in operable cases. I cannot agree with either his premise or corrollary. It is quite true that a short-circuiting of the bowel relieves the growth from irritation and permits of more careful cleansing. On the other hand an artificial anus on the abdomen is far from pleasant. Many cases would be broken in spirit and lose their morale with the presence of such an objectionable opening. Many can be handled very efficiently and comfortably without it. I would urge a colostomy only in the case where radium application would be facilitated by it and where the possibilities of closing it after treatment were good. In impending obstruction it is of course imperative. In the large group of advanced cases who can control bowel function fairly well we leave the decision to the patient.

Fig. 3. Flexible type of rubber bougie applicator designed to afford protection for the uninvolved rectal wall in growths confined to one side.

TECHNIQUE OF RADIUM APPLICATION

The literature affords very little aid in dosage and technique of radium application in rectal cancer. Our own experience has been one of gradual change from applying filtered radium internally only, to a combination of buried emanation, filtered radium internally and externally and, if necessary, surgical exposure to make the application as accurately as possible.

At first we used only one tube of 1 mm. platinum filter in rubber inserted into the stricture or packed against the lesion with gauze where the growth did not involve the entire circumference of the gut. Following this we used tubes of the same filtration but arranged end to end in tandem fashion, enough to extend beyond the limits of the growth above and below. These were inserted in a small rubber tube inside a larger rubber rectal tube to afford some distance, because we soon learned that the rectal mucosa did not stand radiation nearly as well as the mucous membrane in other parts of the body. This factor of irritation of normal rectal mucosa has rendered the treatment of cancer in this location much more difficult than it otherwise would be.

In 1917, we began using radium emanation interstitially and in a previous publication Janeway[3] has mentioned its use in connection with rectal cancer. This method has added more to our improvement in results than all other changes combined. It permits of distributing the radiation throughout the growth so that an accurate approximation can be made. It permits of using both the beta and the gamma radiation thus resulting in a saving of radium energy. It can be introduced into the upper portion of a growth through an abdominal incision and left in

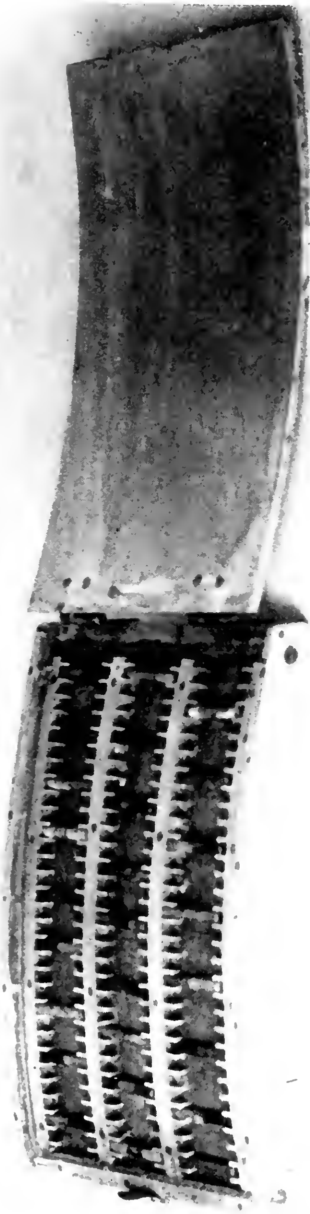

FIG. 4. Radium emanation "pack" used in applying heavily filtered doses over the sacrum.

situ. It permits of a continuous radiation over a period of a few weeks thus resulting in greater dosage being possible than where filtered tubes or needles containing radium element are inserted for a few hours and then withdrawn. These emanation tubes may be inserted, by means of the usual trocar needles, through the proctoscope or as I frequently prefer, if the growth be low down, through a small cannula which is inserted alongside the examining finger. Palpation is always more important than direct vision in inserting radium emanation tubes. The tubes are about 3 mm. in length and 0.3 mm. in diameter and so far we have observed no ill effects from them as foreign bodies. In our earlier work we used tubes of too great strength but now we have reduced the strength of individual tubes and can thereby get a more uniform distribution by using a greater number of tubes. At present we are using tubes of about 1 mc. although in some very bulky growths it is quite safe to use tubes up to 2 mc. in strength. One mc. of radium emanation left in situ until exhausted gives a total radiation of approximately 132 mc. hrs. Depending upon the size and distribution of the growth our dosage of buried emanation varies from 10 to 40 mc. or a total of 1320 to 5280 mc. hrs.

It is frequently possible to introduce these tubes into the rectal tumor without anesthesia because the pain is very slight but I am in favor of a short gas and oxygen anesthesia in most instances. The relaxation by the anesthetic permits of a more accurate distribution of the tubes.

With the early use of buried emanation we fell off very sharply in the use of filtered radium internally. We soon found that this was a neglect of opportunity to get in an appreciable quantity of radiation at close range, and have resumed its use. Where the growth is annular a string of ½ mm. platinum tubes, usually 3 to 5, arranged end to end in a small rubber tube which is again encased in a larger rubber rectal tube with a metal end to facilitate introduction, is placed within the stricture. They may be inserted directly or through the proctoscope. A sufficient number of tubes should be used to go beyond the limits of the growth both above and below. Using this filtration and protection a dosage of 500 mc. hrs. per tube does not give an undue reaction. Where the growth is limited to one segment of the rectal wall a slightly different type of applicator is employed. Solid rubber rectal bougies of various sizes with two grooves cut in the side are employed. In these grooves the required number of platinum tubes in small rubber tubes are placed. Knowing the axis of the growth and its distance from the sphincter

it is possible to insert this applicator so that the tubes come in accurate and close approximation to the growth. If necessary it may be rotated in order to complete the application. This applicator has the advantage of protecting by distance the opposite uninvolved rectal mucosa from the full dose of radium used over the growth. We now feel that it is a distinct advantage to use an internal dose of filtered radium before burying emanation tubes throughout the growth. The surface radiation applied in this way inhibits the growth and produces at least a temporary retrograde process during the course of which it is safer to introduce the needles carrying emanation tubes. The theoretical danger of dissemination by trauma is thereby obviated or materially lessened.

Carcinoma low down in the female rectum offers a more favorable opportunity for treatment because it can be reached through the posterior vaginal wall. For this purpose we use small 2 mm. lead or brass plaques of about 4 sq. cm. surface area as the filtering applicator. One, two, or three of them depending on the individual requirements may be placed over the posterior vaginal wall and the other walls packed away with gauze packing. It is best to separate the plaques about 1 cm. from the posterior vaginal wall and at this distance 800 mc. hrs. per plaque with the lead or slightly less with the brass, can be given with safety in addition to that already used within the rectum. This adjunct is of most value of course where the growth is low down and involving the anterior rectal wall.

At first we were disposed to apply all of our treatment from within but more recently we have been convinced that it is necessary to attack rectal cancer from every available angle if we are to hope for complete regression of the disease with any degree of uniformity. We have therefore resorted to heavily filtered doses of radium applied at a distance from the skin over the sacrum and, if the growth be higher up, through the left lower quadrant as well. For this purpose our usual 70 sq. cm. radium pack is used. This pack is filtered by 2 mm. of brass, and at a distance of 10 cm. from the skin 20000 mc. hrs. of radiation can be given with safety. We feel that this adds very materially to the ultimate result.

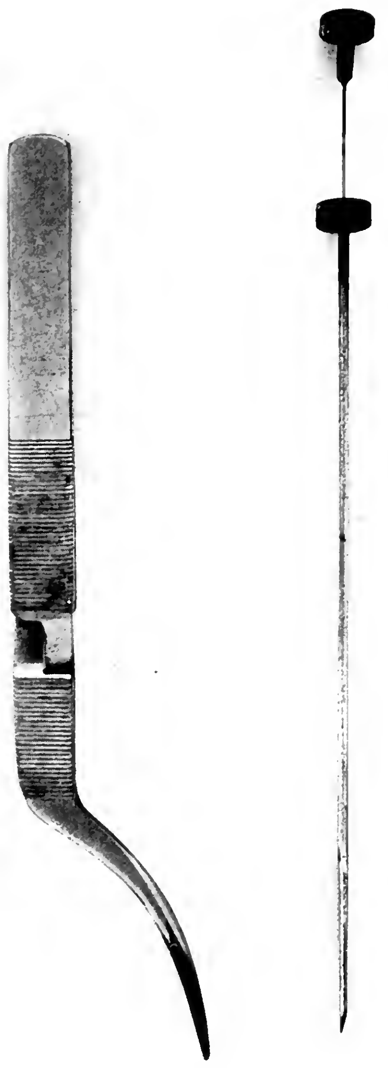

Fig. 5. Showing unfiltered radium emanation tube, trocar needle, and forcep used in placing tube in end of hollow needle.

While our dosage has always been directed toward giving as much as possible with a given applicator, our technique, it will be seen, has changed very materially in the past year. We feel that with this effort to deliver as much radiation from as many avenues of approach as possible in the cases for whom we hold out a possibility of complete regression, our results have been much more encouraging.

FIG. 6. Microphotograph showing early changes due to external radiation on rectal cancer.

FIG. 7. Microphotograph showing marked degenerative changes due to burying radium emanation within the growth.

PRESENT CONCLUSIONS ON METHODS OF TREATMENT

Every case of rectal cancer presenting for treatment should be classified in one of three groups depending on extent of primary growth, metastases or probability of metastases, age and general physical condition.

GROUP I. All cases for whom a reasonable hope for complete regression can be entertained.

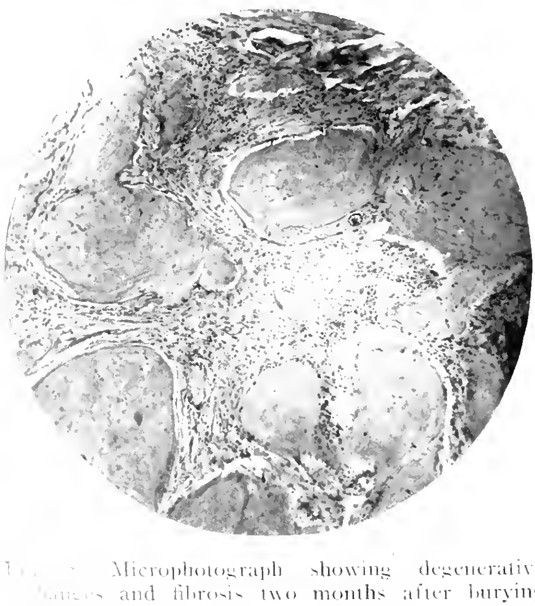

FIG. 8. Microphotograph showing degenerative changes and fibrosis two months after burying radium emanation in rectal cancer.

GROUP II. Advanced cases for whom a reasonable hope for palliative relief can be entertained.

GROUP III. Hopelessly advanced cases for whom the physical agents hold out no chance for relief.

Such a classification is of course very vague and with further improvement in technique will be gradually changed.

However, some such scheme must be adhered to in order to formulate a plan of treatment for each individual case.

It is only human to suppose that Group III will always be with us but let us hope that with better medical education, lessening of fear and distrust on the part of the patient, and improvement in technique with the physical agent it will be steadily reduced. For these patients with disease far advanced both locally and regionally, and with general physical condition markedly deteriorated it is better to do nothing except to pay attention to hygienic measures and medicinal relief. An occasional colostomy may of course be necessary but this should be decided on the merits of the individual case.

In Group II we should give first consideration to the comfort of the patient throughout. If surface applications of radium internally will relieve discharge, bleeding, pain and obstruction and prolong life then it should be employed with that end in view

but not pushed to the point of serious discomfort. I believe that in these cases buried emanation should be used sparingly, if at all. The reaction from it in large doses is too severe to warrant its use for purely palliative relief. In some cases a colostomy may be an urgent necessity but as a general rule it should be left to the decision of the patient, after he has been acquainted with the facts.

In Group I we should make use of radium in as large doses as possible and through all available channels to effect a complete regression. In the majority of these cases I am convinced that an exploratory laparotomy is advisable. It can be done usually under local anesthesia with very little risk to the patient. It establishes definitely the advisability or not of pursuing radical treatment. It frequently offers a much more accurate means of introducing radium emanation into the upper portion of the growth. If it is found that a temporary colostomy will facilitate treatment it can be done at the same time. In many of the smaller growths a laparotomy is not essential for localization of the disease. They can be treated very accurately through the proctoscope and a colostomy need not be considered. In these therefore we can afford to gamble to a certain extent on the absence of regional or distant metastases. Treatment of these smaller lesions is not attended by an appreciable amount of discomfort but I feel that we are fully justified, in the light of our present experience, in subjecting a patient to this where there is a reasonable hope for complete regression of the disase. Emanation in sufficient amount should be distributed accurately and uniformly throughout the growth, preferably under gas and oxygen anesthesia. Filtered radium should be applied internally in every way that the anatomical relations of the individual case permits. Filtered radium should be applied at a distance from the skin and in maximum dosage over the sacrum and, if the growth be high up, over the left lower quadrant as well.

In certain cases, especially bulky growths involving the small sphincter, surgery may be employed to advantage after intense radiation.

I have made no mention of surgery for the so-called strictly operable cases. The statistics of surgery alone in these cases are before us and leave much to be desired. Unfortunately sufficient time has not elapsed to permit of radium statistics from improved methods of application.

We feel, however, that our experience throughout this period of evolution in technique and methods of radium application warrants us in treating the operable as well as some of the more advanced cases, with a reasonable hope for success.

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DISCUSSION

Dr. Henry K. Pancoast. Dr. Quick has given us an excellent presentation of the technique of the treatment of this condition as it should be carried out. I doubt if any of us have carried out as thorough a technique in the treatment of carcinoma of the rectum as has been given. We all realize that carcinoma of the rectum, as it comes to us, is a usually hopeless condition. It is a very good example of the necessity for early diagnosis when such cases can be treated successfully, if ever. How often is the patient who has a little bleeding from the rectum and pain given a salve and told to take some other treatment for hemorrhoids instead of a careful examination being made? Certainly women who complain of persistent bleeding from the uterus are not given such treatment, and there is just as much necessity for paying attention to these cases of rectal bleeding as to the uterine.

So the cases that come to us are usually palliative and the treatment must be palliative to relieve the patient to a certain extent. Take the latter class first. All we can do is to keep the passage open for as long as possible and keep the patient comfortable. We can do this in most cases for a comparatively long time. Dr. Quick has said for two years, and I can bear him out in this statement. If we regard the case as a little more favorable, and yet it is still palliative,—we must regard the cases from all points of view. One of the most important points is free access to the growth. In the treatment of carcinoma of the face or mouth we expect to have free access, and we need this in the rectum just as in any other part of the body to get the best results.

I think the preliminary laparotomy is of great importance, and a procedure we have not carried out except in one or two instances. In one of these we were amazed to see the extent of the growth, and we had to let the patient go practically untreated. I do not doubt that many cases which we have treated as rectal carcinoma also have widespread metastases in the pelvis and even up in the liver. Such cases are usually better off without radiation, but simply a colostomy to relieve the pressure and obstruction. If metastases extends into the prostate and bladder it is folly to treat such cases for they will be made more uncomfortable by any sort of treatment.

Our statistics cover 15 to 20 cases, and in thinking over those cases to decide whether it was better to do anything, we can pick out say 4 out of 16, or 25 per cent, in which we feel we have done the patient some good. One patient is still living following a colostomy five years ago. Another patient was free from symptoms for about three years when there was a recurrence from which she subsequently died. Another patient has been kept in comparative comfort for three years by the introduction of tandem tubes to keep the stricture open. We did not attempt to do anything further and he has movements every day if the stools are kept soft. Another patient has been kept well for five years and is able to ride around on a bicycle and has reduced his morphine from 20 grains to 2 or 3.

As to the technique, I am glad to hear, as a preliminary part of the technique, of the exploratory laparotomy which I think is well worth while; then a colostomy if it is needed; then free access to the growth, whatever that may mean. It may mean partial surgery, it may mean introduction of the needle from above, if necessary, and this cannot be done unless one uses emanation tubes, which I have not been able to do. If the growth is annular, the tubes must be used in the lumen and one must watch the remainder of the rectum. We must look for metastases, and I think no case is properly treated without cross-firing with x-rays, from both front and behind. Whatever treatment we can give inside is only part of the treatment and we must depend upon cross-fire radiation from the outside to supplement it.

Dr. George E. Pfahler. I have only had experience with inoperable cases. I think all of these are undesirable cases as far as the pleasure of working at them is concerned, and because the outcome of any case of carcinoma of the rectum is likely to be unfavorable, but I have used a combination of methods that has not been mentioned, and it is for that reason that I speak.

In 3 different cases I destroyed the growth locally by means of electro-coagulation, and in 2 of these cases I then introduced a radium pack or tampon similar to the one described by Dr. Quick and treated them by cross-firing with the x-rays externally. One patient lived three years and then seemed to die of toxemia. He had a marked stricture of the rectum and I believe his death was due to toxemia from retained feces. This man had had three operations before he came to me and would not permit another. The second patient who was treated by this method for a year has been attending to his usual duties which are rather strenuous. He has a stricture of the rectum so that the lumen is perhaps ½ or ¾ of an inch. Aside from that he is free from symptoms and goes about his duties. We must expect a constriction that will result both from scar tissue and radium application. The third case I treated by this combination is more recent and is doing well and I believe it is a form of treatment I would use again.

I first radiated to the limit of skin toleration externally, requiring a period of two weeks. Then I destroyed the growth, which was approximately three inches in length and about two in width and filled the rectum, by means of electro-coagulation. Then immediately in the pieces of this tumor, or what was the tumor, I introduced 150 mgm. of radium in the form of needles, and a week later introduced a radium tampon and we shall follow up that by cross-firing with the x-rays, which I believe gives us a very good method of treatment.

Dr. H. H. Bowing. I wish to mention another type of anesthesia. That is caudal or sacral anesthesia, which we feel is very helpful.

One of the elements of failure in the treatment of these cases is the poor exposure of the lesion afforded by ordinary methods. Caudal or sacral anesthesia is a very satisfactory procedure. The technique at the Clinic is that of Dr. Labat. It not only assists the operator but offers in many ways relief of pain to the patient. Owing to the liberal amount of sphincter relaxation, an extra large proctoscope is used. Following the radium application in some of these cases, the exposure of the lesion was so complete that it seemed efficacious to give *x*-ray treatments through the proctoscope. Time intervals are too recent to determine the result in this type of therapy.

Dr. R. E. Loucks. We have considered the treatment of the disease very well, but aside from that I think we should treat the patient. I think if any patient suffers it is the one with proctitis, especially from radium. The colostomy gives us a good source for irrigation of the lower bowel, and I have found that it affords the patient great comfort to give an irrigation at least twice a day with an alkaline solution. I have found that a solution of boracic acid or chlorate of potassium has given these patients much comfort. Then sometimes, as you know, we have to resort to opiates, but the treatment with morphine gradually creeps up, so we use morphine by suppositories.

I think the after-treatment is of much importance, for these patients suffer a great deal. They have an inflamed condition and a great deal of secretion from the cells and this produces much discomfort in the external folds of the anus.

The diet in these cases is another consideration. I think the diet should be regulated. The idea of allowing people who have a proctitis to eat all kinds of highly seasoned foods is a mistake. If we had a diseased eye we would have it covered up, but if the rectum is involved we often allow patients to eat anything they wish and it sets up a great deal of irritation. They should have plenty of food and alkaline fluids.

Dr. Douglas Quick (closing the discussion). I think Dr. Loucks summed the whole thing up when he said "treat the patient". I think a great deal of the treatment is in keeping the patient comfortable. It is just for that reason that I urge classifying these cases before we start and not starting at random and seeing where it leads us. There are certain cases in which I think we can reasonably hope for complete regression. These people I think we should treat to the limit. They do suffer, there is no question about that. They have pain, they lose some weight, have marked toxemia, and that sort of thing, but that I think is well worth while if we have some light on the other side to look forward to. In these cases I want to urge again the exploratory laparotomy to see where we are. Just a few weeks ago we had four cases in one week in whom we did exploratory laparotomy, and three had extensive liver metastases. I think it would have been a shame to put these patients through the radical treatment, which would have caused them great discomfort. There are some cases with the small early lesions, in which the suffering is not so marked.

I wish to congratulate Dr. Pfahler on the use of electro-coagulation, and this is one class of cases in which I think we should get very good palliative results with a minimum amount of discomfort.

The use of *x*-rays externally, as mentioned by Dr. Pancoast, is followed by us and we have had some results. In the group which we look upon as favorable we have tried to use as much radium as possible.

PATHOLOGICAL CLASSIFICATION OF THYROID GLAND DISEASES WITH RADIUM TREATMENT IN TOXIC GOITER*

By R. E. LOUCKS, M.D.

DETROIT, MICHIGAN

IN this day of distinctive entities it is absolutely essential that a disease of certain glands or organs should be classified according to the pathological condition present. Whether it is acute, subacute, or chronic is another important consideration.

In diseases of the thyroid gland it is imperative to have three general classifications

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with one or two subgroups following each class.

1. INFLAMMATIONS
   - (a) Acute purulent thyroiditis (rare)
   - (b) Tuberculosis of thyroid
   - (c) Diffuse interstitial thyroiditis
   - (d) Interstitial thyroiditis as in pellagra
2. TUMORS
   - (a) Carcinoma
   - (b) Carcinoma sarcomatodes
   - (c) Sarcoma
3. DYSTROPHIES
   - (a) Colloid retention hyperplasia
     1. Colloid goiter (diffuse)
     2. Circumscribed colloid adenomata (cystic)
   - (b) Proliferating type
     1. Adenoma
     2. Fetal adenoma
     3. Adenoma with toxic changes
     4. Primary exophthalmic goiter as a selective type.

For a clinical classification of hypo- and hyperthyroidism we are indebted to Plummer who groups them as follows:

1. HYPOTHYROIDISM
   - (*A*) Cretinism
   - (*B*) Myxedema
2. HYPERTHYROIDISM
   - (*A*) Thyrotoxic adenoma
   - (*B*) Exophthalmic goiter
3. NONTOXIC ENLARGEMENTS
   - (*A*) Adenomas—nontoxic
   - (*B*) Adolescent goiter
   - (*C*) Colloid goiter

As we are to discuss the treatment of the toxic or active type of this gland it would be fitting to enumerate certain toxic changes and emphasize the cardiac and general degenerations. Whether there is a selective poison to produce a primary exophthalmia in one case, and an active thyrotoxic adenoma with exophthalmic symptoms in another, we shall not discuss here.

The toxic adenoma produces a sequence of symptoms different from the exophthalmic type. There is no sudden exacerbation but a general increasing chain of symptoms over a period of years, after the enlargement of the gland is noted. It may have started in the teens and existed many years before toxicity was observed.

Exophthalmic goiter with few exceptions runs a typical course. The thyroid gland may not show any enlargement, or a very slight one at first with mild toxic symptoms which gradually increase in severity until about the eighth month, when they are markedly worse; this is commonly known as a crisis. After this explosion of symptoms, there is improvement with fairly constant symptoms, until the end of the second year, when a second crisis occurs. Hereafter the active symptoms may subside slightly, or run an up and down course. The individual may exist as a human wreck for years, or the cardiac and general degeneration progress so rapidly as to cause termination of life.

The thyroid is termed the principal "regulator of metabolism." It is the main link in the chain of endocrinal glands.

The clinical manifestations of thyroid activity may be corroborated by means of one of the metabolor apparatus.

The process of combustion within the body depends upon the intake of the essential element, oxygen. The physics of physiology has standardized this oxidation with its output of carbon-dioxide (at a certain temperature standard and barometric pressure), so that the caloric value of oxygen may be determined.

With hyperactivity of the thyroid there is marked increase in cellular activity with a speedy demand for larger oxygen consumption. To estimate the rate it is only necessary to measure the amount of oxygen consumed in a given period of time and make your calculations by physiological standards for body surface, temperature and barometric pressure.

This will give the number of calories per square meter per hour, and is known as the "metabolic rate." With forty as the standard, and knowing that there are normal variations on account of age, seasonal and climatic variations, an allowance of 10 per cent, either above or below, is recognized.

With hyperactivity, the basal metabolic rate is increased in proportion to the clinical evidence of toxicity. McCaskey says: "The value of basal metabolism determinations in proving the pathogenic role of thyroid hyperactivity has been confirmed by additional experience. Probably more than 90 per cent of all cases showing increase in

metabolic rate are due to hyperthyroidism. Other endocrine glands play a small subordinate role".

The exophthalmic type at first gives a slight increase in blood pressure, which after the first crisis, falls to normal, or below normal, and again increases and remains high.

Etiology. There are many views and opinions on the cause of thyroid hyperactivity. "Thyroid centers" is a term used to designate certain locations, as Michigan, Minnesota, and Switzerland, where there appears a preponderance of the disease.

Fear, shock and violent emotions are factors that may precipitate an activity, but focal infections from tonsils, adenoids, duodenal and typhoid ulcers are apparently active causes. Many cases are associated with gastric disturbances or general ptosis of the abdominal viscera, also hypo- and hyperactivity of other endocrines at the time of puberty, pregnancy and the menopause.

Symptoms. It is unnecessary to go over the cardinal symptoms to the members of this society but I wish to state a few observations.

Look for an active thyroid with a patient having a florid, blotchy skin, tachycardia without organic heart disease, profuse sweating of the palms of the hands and soles of the feet, longitudinal striae of the nails, a choking or aching pain above the sterno-clavicular articulation.

Many neurasthenics with low blood pressure associated with simple anemia, are found to have a high basal metabolic rate, and are the victims of slow toxic absorption from an active adenoma.

Forewarning symptoms of a bad prognosis are:—

1. Bulging eyes for two or more years.
2. Pale muddy complexion with edema of the extremities.
3. Pulse rate of 140 with irregularity, which is due to fibrillation.
4. High blood pressure.
5. Emaciation with a history of losing weight rapidly.
6. Strong apex impact with pulsation of the intercostal muscles over heart.
7. Cardiac dullness, increased with accentuation of last sound or both sounds of heart.
8. Apex beat counted as 180 with 120 recorded at radial artery.
9. Urinary symptoms of a failing heart muscle.
10. High basal metabolic rate.
11. Persistent diarrhea.
12. Cerebral symptoms and the presence of acidosis.
13. A positive Wassermann.

TREATMENT

The indications are only defined after all the facts have been considered and the case classified, unless some symptomatic relief is urgent. Commence with saline elimination (unless diarrhea is present), rest in bed, non-protein diet, ice bag over thyroid gland and precordia, alkalines internally and alkaline sponge baths.

Strontium bromide may be tried, quinine hydrobromide, ergot, ergotine and sodium cacodylate. If after two weeks of medication with hygienic and dietetic measures, there are still decided evidences of thyroid toxemia you must choose between surgery, *x*-ray and radium.

The wave of opinion today among scientific research workers, is that toxic goiter is not a surgical disease.

After some years of experience and the assurance of my co-workers, I have arrived at the conclusion that radium is the treatment of choice. Aikins of Toronto reported at the meeting of the American Radium Society at New Orleans last April, 100 cases treated with wonderful results, and convinced the most skeptical of the merits of radium.

It is portable, less exciting, more easily controlled, does not produce a sudden toxemia, and results are more promising than with *x*-ray. Supplement your radium treatment with rest, protein-free diet, ice bag to thyroid gland and at times to precordia. Medicate for two weeks if necessary and use alkalies freely.

Radium Treatments: Use 100 mgm. (at least) in four tubes, each tube screened in 1 mm. brass and 1 mm. gum rubber. The screened tubes are placed on a gauze pad 2 cm. in thickness to get distance and protect the skin. Two or three ports are exposed over the gland, depending on the size of the gland, size of the pad and the amount of ra-

FIG. 1. CASE I. J. B.

dium used. The time of exposure varies from eight to ten hours over each port.

With your indulgence I will give brief histories of 5 cases treated, with metabolic readings before, and monthly readings for three months after treatment; also photographs of 3 cases before and after treatment.

CASE I. (June 29, 1920). J. B., male, Solvay Process employee, aged twenty-nine, single. Occupation, repairman.

Complaint. Nervousness, weakness and loss of weight together with enlargement of neck.

Past and Family Histories. Negative

Present Illness. Entered the Solvay Hospital today. For the past six months he has been gradually getting nervous. His neck has also gradually increased in size although it was always large. His condition grew progressively worse, and during this time he lost 40 lbs. in weight.

PHYSICAL EXAMINATION

On admittance he was so nervous that his voice trembled and his jaw shook. Had an alert expectant expression on face. Eyes;—Pupils regular, marked exophthalmos with positive Von Graefe and Stelwagon signs, slight lateral nystagmus. Tongue had a marked tremor.

Neck. Marked enlargement of both lateral lobes of thyroid gland.

Heart. Slight enlargement. Distinct systolic murmur heard all over the precordium. Pulse regular, easily compressible with a rate of 130.

Hands and Fingers. Marked Tremor.

SUBSEQUENT RECORD

Blood counts and urinalysis were made and found normal. Wassermann gave a negative result. Goetch test gave a positive finding. He was nauseated from time to time and vomited occasionally.

On August 27th (two months), the superior thyroid arteries were both ligated and three-fourths of the right lobe and one-half of the left lobe removed. Temperature varied from 99 to 102 F. and he had a stormy convalescence.

He left the hospital October 15, 1920, somewhat better. Temperature was occasionally 99.2 F. with a pulse rate of 100 to 120. Neck showed evidence of increasing enlargement.

From October 15 to November 8, 1920, he lived at home but was treated with thyroidectine.

November 8th, he again entered the hospital for rest and a subsequent operation. His blood and urine were again normal. Caloric value was found to be 120. He was given a high carbohydrate diet, salt free, yet he gradually grew worse. Bromides and thyroid residue were tried but without results.

On January 31, 1921, he was referred to our service.

EXAMINATION

Has some temperature at times. Perspires considerably. Pulse varies from 100 to 130. Systolic blood-pressure, 142; diastolic, 70. Blood count: reds 4,980,000; whites 5,900; polynuclears, 50 per cent; small lymphocytes; 30 per cent; large lymphocytes, 19 per

cent; eosinophile, 1 per cent. Urine, normal.

Upper circumference of neck, $18\frac{1}{2}$ inches; middle, 19 inches; lower, $19\frac{1}{2}$ inches. Basal metabolism rate, 120.

Heart. Apex directly below nipple; cardiac dullness, extends toward the left; distinct systolic (mitral) murmur carried toward the axilla.

The pulse and heart sounds are characteristic of cardiac change besides the endocarditis.

Diagnosis. Exophthalmic hyperthyroidism of an old adenoma. 2. Chronic myocarditis. 3. Chronic endocarditis.

Prognosis. Control toxicity. Relieve work on heart and restore compensation. Reduce thyroid enlargement.

Treatment. Was given 220 mgm. radium in six tubes. Each tube screened in 1 mm. brass and 1 mm. gum rubber, all placed on a gauze pad 2 cm. thick and held over right lobe of thyroid for ten hours, and then over left lobe for ten hours.

March 1st. Eyes less prominent, thyroid smaller, softer, and does not cause tracheal pressure. Apex beat to right of nipple. Radial pulse and apex beat each 88. Systolic blood-pressure, 122; diastolic, 60. Metabolic rate, 68.4281.

Basal Metabolism—March 8, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:14	5150 cc.	29.03	20	5:05½	150
10:20	2650 cc.	29.03	20		
06 min.	2800 cc.	.907 Temp. Centigrade. 4.85 Cal-			
1 hr.	28000 cc.	ories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			

April 8th. Upper circumference of neck, 17 inches; middle, $17\frac{1}{2}$ inches; lower, 18 inches. Pulse 90. Systolic blood-pressure, 130; diastolic, 70. Metabolic rate, 53.7649.

Basal Metabolism—April 8, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:30	6200 cc.	29.11	20	5:05½	150
10:36	4000 cc.	29.11	20		
06 min.	2200 cc.	.907 Temp. Centigrade. 4.85 Cal-			
1 hr.	22000 cc.	ories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			

Two weeks following the first treatment he was better and had his clothes on. Was out of the hospital in four weeks and resumed work in the factory in six weeks. His eyes are less prominent; tongue and fingers more steady; tachycardia less. No nausea since the first week.

Recommended a second treatment. Was given 280 mgm. with the same screening and for the same time as on January 31st.

May 10th. All symptoms better. Pulse 80. Systolic blood-pressure, 120; diastolic, 70. Metabolic rate, 56.766, which is a few points above April 8th reading, and due to treatment four weeks ago.

Basal Metabolism—May 7, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:49	6400 cc.	29.24	19	5:05½	151
10:55	4100 cc.	29.24	19		
06 min.	2300 cc.	.916 Temp. Centigrade. 4.85 Cal-			
1 hr.	22300 cc.	ories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			

Case II. (March 9, 1921). S. R., female, aged thirty, married. Occupation housewife.

Complaint. Enlarged neck and nervousness; duration three years.

Family History. Negative.

Personal History. Enjoyed good health until three years ago. Menstruated at eighteen years; always regular. Is the mother of two living children, one six and the other four years of age.

Three years ago she complained of pain around her heart and between her shoulders with loss of voice. She is disinclined to work; has difficulty in breathing and on going up stairs; perspires freely, has lost nearly all of her hair; is very nervous; appetite poor and sleeps very little. She has indigestion and constipation and falls down occasionally; is afraid to stay alone; lost about fourteen pounds in weight.

PHYSICAL EXAMINATION

Radial pulse rate, 100. Apex rate, 160. Systolic blood-pressure, 180; diastolic 90. Upper circumference of neck, $15\frac{1}{2}$ inches; middle, 16 inches; lower $16\frac{1}{2}$ inches. Weight, 158 lbs. Metabolic rate, 88.8282.

Basal Metabolism—March 7, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:55	5600 cc.	29.31	20	5:07¾	153
11:01	2000 cc.	29.31	20		
06 min.	3600 cc.	.913 Temp. Centigrade. 4.85 Cal-			
1 hr.	36000 cc.	ories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			

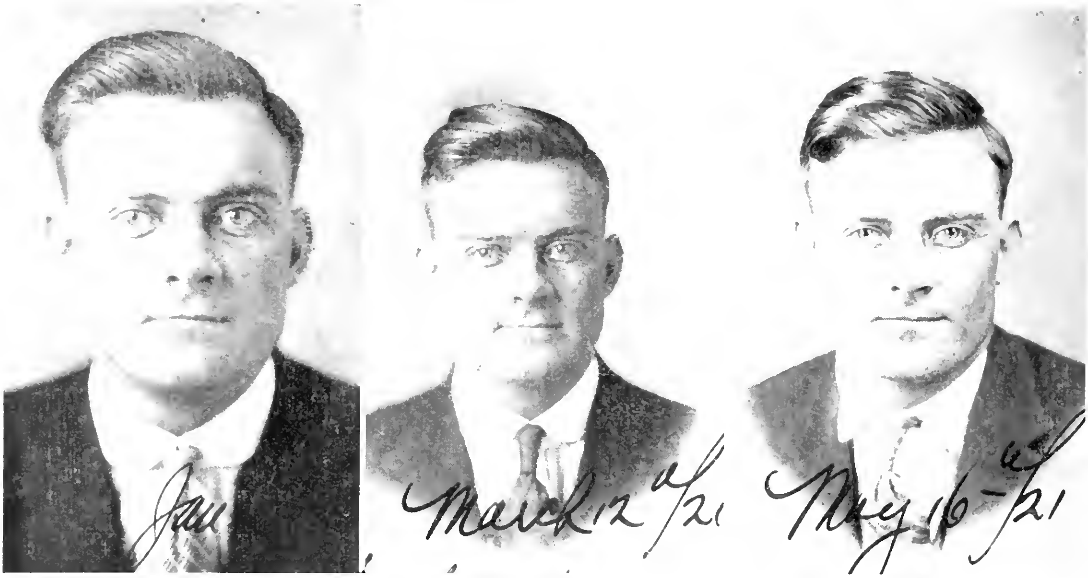

FIG. 2. CASE IV. S. H.

BASAL METABOLISM—March 31, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:45	5800 cc.	29.22	21	5:07¾	148½
10:57	3200 cc.	29.22	21		
06 min.	2600 cc.	.910 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			
1 hr.	26000 cc.				

Skin blotchy and moist. Perspires so freely that adhesive tape would not hold. Tongue tremulous. Thyroid enlarged with the right lobe larger than the left.

Pulsation seen along the great vessels of the neck and a bruit heard over the left lobe of the thyroid.

Anterior left chest heaving with every heart beat and pulsation seen between the ribs overlying the heart. Heart sounds so rapid that it was hard to distinguish a murmur at the apex which was referred toward the left axilla.

Fingers crooked in a flexed position with a marked tremor on extension. Nails of a poor quality and striated.

Diagnosis. Exophthalmic hyperthyroidism (having passed the second crisis).

Prognosis. Control the toxic symptoms and lessen heart activity, and thus make her more comfortable and prolong life.

Treatment. Was given 180 mgm. of radium in six tubes, each screened in 1 mm. brass and 1 mm. gum rubber. Made into a gauze pad 2 cm. in thickness and applied over each lobe of the thyroid for ten hours; total of twenty hours.

FIG. 3. CASE VI. G. G.

March 31st. Three weeks after treatment her metabolic rate was 63.7505.

April 30th. Apex heart beat, 120. Systolic blood-pressure, 160; diastolic 80. Upper circumference of neck, 14½ inches; middle, 15½ inches; lower 15½ inches. Weight, 149½ lbs. Metabolic rate, 59.6556.

BASAL METABOLISM—April 30, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:24	6575 cc.	29.31	20	5:07¾	154½
10:30	4150 cc.	29.31	20		
06 min.	2425 cc.	.913 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			
1 hr.	24250 cc.				

CASE III. (February 16, 1921). K. R., male, aged seventeen, single. Occupation, farmer.

Complaint. Shortness of breath and nervousness.

Family History. Negative.

Personal History. Was well until thirteen years of age, when he complained of headaches and a cough. Had eyes examined and wore glasses without relief.

Was compelled to leave school when fifteen years of age. Had influenza which affected his heart so that it has been giving trouble ever since.

Last June had an appendiceal abscess which ruptured and was afterwards surgically drained. Made a good recovery but has an abdominal hernia. The rest in bed at the hospital improved his nervous condition.

PHYSICAL EXAMINATION

Eyes prominent, right eye more than the left. Thyroid area of the neck full and bulging. Tonsils not enlarged but red, and have many crypts.

Chest. Precordial pulsation. Apex beat slightly toward the left. Second heart sound accentuated but no murmur detected. Radial beat, 96; apex beat, 112.

Fine tremor of fingers on extension with longitudinal striae of nails. Systolic blood-pressure, 148; diastolic, 90. Weight, 150 lbs.

BASAL METABOLISM— February 17, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:15	6000 cc.	29.34	20	5:08¼	150
10:21	2400 cc.	29.34	20		
06 min.	3600 cc.	.913 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.9 Body surface. (Du Bois Chart)			
1 hr.	36000 cc.				

Metabolic rate, 83.8998. Upper circumference of neck, 15¼ inches; middle, 15½ inches; lower 16 inches.

Diagnosis. Exopthalmic hyperthyroidism clinically caused by influenza infection and subsequently rekindled by pus from an appendicular abscess.

Treatment. Was given 220 mgm. of radium in six tubes, each tube screened in 1 mm. brass and 1mm. gum rubber, all laid on a gauze pad 2 cm. in thickness and held over right lobe of thyroid for ten hours, then over the left lobe for eight hours.

March 28th (forty days following the treatment). Metabolic rate, 77.2382.

BASAL METABOLISM—March 26, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
3:58	6000 cc.	29.71	22	5:08½	143
4:04	2800 cc.	29.71	22		
06 min.	3200 cc.	.919 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			
1 hr.	32000 cc.				

May 20th. His eyes are normal in appearance. Complains of no cardiac pain or distress on exertion. Has no sweating, and in fact his thyroid symptoms are negative.

Pulse rate, 82. Systolic blood-pressure, 126; diastolic 86. Weight, 143 lbs. Metabolic rate, 44.1350. Upper circumference of neck 14¾ inches; middle, 14¾ inches; lower, 15 inches.

BASAL METABOLISM—May 21, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:18	6400 cc.	29.54	23	5:08½	142
10:24	4600 cc.	29.54	23		
06 min.	1800 cc.	.910 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.8 Body surface. (Du Bois Chart)			
1 hr.	18000 cc.				

CASE IV. (January 26, 1921). S. H., male, aged twenty-four. Ex-service. Occupation, bank clerk.

Complaint. Pain in left chest and nervousness.

Family History. Negative except that one sister was operated on for goiter.

Personal History. Always enjoyed good health. Smoked very little. Appetite good. Nervous and has pain in left side of chest on walking fast or on excitement. Perspires

freely on palms of hands and soles of feet.

Was in the service ten months. When discharged had a pulse of 120. Went home and was under the care of his family physician for three weeks. Later examined at the Marine Hospital and was sent to the Shurley Hospital for treatment. Remained in the hospital nine weeks. Had neck painted with iodine and had sixty-three violet ray treatments of left chest. Left the hospital feeling no better.

Had tonsilectomy done three months ago. Was referred to our service.

PHYSICAL EXAMINATION

Pulse 90 to 100. Systolic blood-pressure, 122; diastolic 78. Weight, 166 lbs. Metabolic rate, 53.2989.

BASAL METABOLISM—January 25, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:18	7150 cc.	29.8	21	5:09¾	166½
10:24	4900 cc.	29.8	21		
06 min.	2250 cc.	.928 Temp. Centigrade. 4.85 Calories per hour. 1.9 Body surface. (Du Bois Chart)			
1 hr.	22500 cc.				

Upper circumference of neck 16½ inches; middle, 16¾ inches; lower, 17½ inches. Eyes are prominent with sclera showing around the cornea for ⅛ inch. Tongue tremulous.

Heart slightly dilated to the left with accentuation of second sound. A systolic murmur heard at apex which is referred toward axilla.

Neck prominent and enlarged over thyroid gland. The right lobe of thyroid is soft with a small cyst near the trachea. The left is enlarged but smaller than the right. The isthmus is also cystic.

The palms of the hands are wet with perspiration. The fingers tremulous on extension.

Diagnosis. Exophthalmic hyperthyroidism.

Treatment: Was given 180 mgm. in four tubes, each screened in 1 mm. brass and 1 mm. gum rubber. The tubes were laid on 2 cm. of gauze as a pad, and held over the right and left lobes of thyroid for ten hours each.

BASAL METABOLISM—February 25, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:16	5200 cc.	29.21	17	5:09¾	167
10:21	2650 cc.	29.21	17		
05 min.	2550 cc.	.922 Temp. Centigrade. 4.85 Calories per liter oxygen. 2.0 Body surface. (Du Bois Chart)			
1 hr.	30600 cc.				

Four weeks after the treatment of February 25th, his metabolic rate was 68.4170, an increase of fifteen calories, which goes to prove that from the third to the fifth week after the treatment there is an increase in metabolism. Yet he was able to return to his bank position two weeks after the treatment.

April 8th. He feels perfectly well. Has none of his former symptoms. The eyes are less prominent and the neck measurements have decreased from 1 to 1½ inches. Caloric value found 39.4908.

BASAL METABOLISM—April 8, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:06	6200 cc.	29.12	20	5:09¾	167½
10:12	4450 cc.	29.12	20		
06 min.	1750 cc.	.907 Temp. Centigrade. 4.85 Calories per liter oxygen. 2.0 Body surface. (Du Bois Chart)			
1 hr.	17500 cc.				

May 14th. Caloric value found 31.585.

Metabolic rate 31.38 today, which is only ten weeks since the treatment.

BASAL METABOLISM—May 14, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:04	5500 cc.	29.3	19	5:09¾	166½
10:10	4150 cc.	29.3	19		
06 min.	1350 cc.	.910 Temp Centigrade. 4.85 Calories per liter oxygen. 1:9 Body surface (Du Bois Chart)			
1 hr.	13500 cc.				

CASE V. N. L., female, January 24th, 1921. Aged thirty-nine, married. Occupation, housewife.

Complaint. Nausea, vomiting and weakness; duration, four years.

Family History. Negative.

Personal History. As a child enjoyed good health. Menstruated at fourteen years. Has always been regular. Is the mother of two children, one nineteen and the other fifteen years of age. Had four miscarriages. Menopause at thirty-five.

Has had diarrhea off and on for the past eleven years. Used to faint and have dizzy spells and lose her voice at times. Troubled

with headaches; is disinclined to work; perspires freely; is extremely nervous, cries easily and wants to be alone.

Two years ago had a partial lobectomy performed. Has lost over twenty pounds in weight since last November. All her symptoms have greatly increased until now she is a nervous and physical wreck.

PHYSICAL EXAMINATION

Radial pulse, 130. Apex beat, 150. Systolic blood-pressure, 150; diastolic, 90. Upper circumference of neck 13¼ inches; middle, 14 inches; lower, 15½ inches. Weight, 118 lbs. Metabolic rate, 167.6887.

BASAL METABOLISM—January 24, 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:45	7000 cc.	29.13	15	5:07½	120
10:50	2000 cc.	29.13	15		
5 min.	5000 cc.	.922 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.6 body surface. (Du Bois Chart)			
1 hr.	60000 cc.				

She has a frightened anxious expression with both eyes bulging. The right worse than the left. Skin blotchy and muddy looking, with many pimples on face and shoulders which may be due to bromides. Tongue tremulous, both thyroid lobes enlarged and cystic.

Chest. Pulsation with every heart beat; atrophy of intercostal muscles.

Heart enlarged in all directions. A distinct systolic murmur heard at apex which is referred toward the axilla and upward to the left second intercostal articulation; murmur of a rough grating type that would suggest myocardial as well as endocardial change.

There is extreme muscular atrophy of arms and limbs. Fingernails brittle and with longitudinal striae. Fingers, hands and arms in extreme tremor on extension. Has edema of both ankles. Can only walk a few steps at a time. Been confined to bed for some weeks.

Diagnosis. Exophthalmic hyperactivity of an old thyroid adenoma.. Much degeneration of all important organs and glands.

Prognosis. Lessen toxicity and activity, and make her more comfortable.

Treatment. Was given 180 mgm. radium in six tubes, each screened in with 1 mm. brass and 1 mm. gum rubber and made into a gauze pad 2 cm. in thickness which was held over the left lobe of thyroid for eight hours then over the right lobe for ten hours; total of eighteen hours.

May 19, 1921. Patient is able to be around and attend to all her housework. Has no nausea or vomiting, sleeps well, has a good appetite and gained 12 lbs. in weight.

All of the symptoms have decreased in severity even to the eye prominence.

Four months ago she was confined to the bed while today she walked into the office.

Radial pulse and heart beat, 120. Systolic blood-pressure, 80. Upper circumference of neck 12¾ inches; middle, 13½ inches; lower, 14½ inches. Weight, 130½ lbs. Metabolic rate, 87.8069.

BASAL METABOLISM—May 20th., 1921.

Time	*Reading*	*Barom.*	*Temp.*	*Height*	*Weight*
10:20	7600 cc.	29.54	21	5:07½	130½
10:15	4800 cc.	29.54	21		
05 min.	2800 cc.	.916 Temp. Centigrade. 4.85 Calories per liter oxygen. 1.7 Body surface. (Du Bois Chart)			
1 hr.	33600 cc.				

CONCLUSIONS

1. The systolic blood-pressure is lowered in those cases with a high blood-pressure where the degeneration of the heart and kidneys has not become permanent.

2. The blood-pressure is raised in those where compensation is reestablished.

3. In those cases with a metabolic rate around 80 it was lowered for the first two weeks; raised for the third and fourth weeks, and then gradually decreased for the next few months.

4. In those with a metabolic rate above 100 with broken compensation it gradually decreased after the third week.

5. The metabolic rate was found to be normal in many very active cases three months after treatment.

6. Metabolism being the standard of toxic activity, the rate measurement will verify clinical findings, prove results of treatment, and show a physiological indication for future measures.

DISCUSSION

Dr. W. H. B. AIKENS. Dr. R. E. Loucks, in his paper and demonstration, has given us a valuable contribution to the advance made in

treating hyperthyroidism with radium, and one cannot speak too highly of the value of radium in toxic goiter.

I agree thoroughly with the reader of the paper that hyperthyroidism and toxic adenomata should no longer be regarded and classed as a surgical diseases, as the nervous and heart symptoms are in no way conducive to successful operation. Radium treatment is not accompanied by the risks and horrors of operation. But if, for cosmetic reasons, following the disappearance of the toxic symptoms, an operation is insisted upon by the patient, the fact that the radium has been used does not materially increase the surgical removal, though a good deal of fibrosis may have occurred and some firm adhesions may have been formed.

It may be interesting to note that eight years ago I read a paper in Toronto on this subject and Dr. Loucks was good enough to come over and hear it. It was suggested that it might be well to have the men meet who were taking a deep interest in radium therapy. The first constructive meeting was held in Detroit, when it was decided to form a radium society. A committee was appointed to frame a constitution, which later in the year, was adopted at a meeting in Philadelphia. I would not say that the subject of hyperthyroidism was the incentive to the formation of the American Radium Society but it certainly helped to bring it about.

As to the dose administered, I believe in moderation, and am glad to learn through correspondence with Dr. Pfahler that he views the smaller doses as being efficient. I know of one case where about 4,000 milligram-hours were administered, the result being apparently an entire obliteration of the thyroid gland with unfortunate after-results, as myxedema supervened and thyroid tablets are now being used.

Dr. George E. Pfahler. I have read Dr. Aiken's article and have had considerable correspondence with him and think I can agree with the things he says and the things that Dr. Loucks has referred to. I have had more experience in the treatment of these cases with *x*-rays, and as a rule I treat the patients who are able to come to my office with *x*-rays because I can get through with them and get them out and I have had excellent results. The patients who are bedfast and must stay in the hospital can afford to be treated there with radium, with equally good results—sometimes superior. In one case I was unable to influence the growth with *x*-rays, but got an excellent result from radium.

I would like to emphasize the importance of getting rid of focal infection in the teeth, tonsils, sinuses, and even in the gall-bladder and appendix. In one patient in whom I was not getting any response from radium we searched everywhere for focal infection and finally she had a definite group of symptoms pointing to the appendix. She then gave us a history that she had not given previously. You must all realize how often patients do not give us all the history. This patient then told me about the symptoms which pointed to involvement of the appendix for at least six years. The appendix was operated upon, a pus tube found, and she then began to improve. I have had some cases in which I got no result until I had abscesssed teeth removed. Now I make it a rule to examine the teeth of every patient who comes to the office for treatment, and if they do not have the teeth removed as I recommend they drag along and not much is accomplished until they do this.

I have used radium needles as surface applications rather than the larger capsules because I can get a wider and more even distribution over the tumor tissue. It is a mere matter of determining how much to use. I have been using 10 mgm. each, filtered through the thickness of the needle plus a millimeter of brass, and placed about 1 cm. apart at a distance of 2 cm. through cotton, and I have used them for from eight to sixteen hours. I noticed in Dr. Aiken's article he prefers to use smaller amounts of radium and longer periods.

I was rather surprised to hear Dr. Loucks say he used 200 mgm. on one side and then on the other. I have seen bad results from too much radium at the first application and would be afraid to use it in that quantity.

Dr. John Lincoln Bower. I just wish to cite a little experiment carried out in the thyroid of the dog. A needle was inserted and the gland was removed at the end of two weeks and showed practically no results except possibly the atrophy of the nucleus, which we observed in the metastatic glands. This was increased, and the glands removed at the end of two weeks showed a beginning fibrosis.

Dr Albert Soiland. It is a pleasure to listen to such a paper as that of Dr. Loucks, and when we can get the ocular evidence he shows, I think it is distinctly worth while. I had the pleasure of presenting a paper on a similar series before the Radiological Society of North America last year, and my results were much like his. We have to be careful in treating adenomata; the surgeons will get

after us if we try to treat these, but the metabolism test is doing much for us in determining when our agents are demanded. We are now treating a series of cases. which are being subjected to monthly metabolic tests. We are going to keep an accurate record and hope to present a tabulation of these cases at the next meeting.

Dr. R. E. Loucks. (closing the discussion). I only wish to comment on the point regarding focal infection. I think I emphasized the importance of removing any focal infection. One of the case reports I did not read was interesting. A man had a severe infection which left him with a bad heart. He had to leave school and later developed an appendiceal abscess which ruptured and had to be drained surgically. At that time his thyroid gland was badly affected and he was treated. He had a metabolic rate of 80, but after one radium treatment it was only 38. We know that focal infection is the thing to get after.

As to the dosage given, I think it is as nearly correct as it is possible to get it. I thought from 100 to 200 mgm. for eighteen or twenty hours was about right. Do not use the same amount of hours because I or anybody else said so, but use your judgment. Increase your alkalinity as you go along, by giving sodium bicarbonate and more sugar. The blood chemistry and urinalysis we learned were of small significance in the hyperthyroidism, unless you have a decompensated heart, with a kidney involvement.

I think a man who has had experience will not over-dose his cases as Dr. Aikens spoke of. You have to use judgment. We know that a blonde individual will not stand as much radiation as a brunette. If you get a radial pulse of 80 and an apex beat of 180, that tells you something. When you get a heart muscle of that kind you must not overload those people.

AMERICAN LITERATURE ON RADIUM AND RADIUM THERAPY PRIOR TO 1906*

By CARROLL CHASE, M.D.

BROOKLYN, NEW YORK

VERY soon after the discovery of radium by Professor and Madame Curie in 1898, certain of the medical profession became interested in the therapeutic possibilities of this newly discovered element and source of energy. This research was naturally promptly reflected in the medical and other scientific journals of the day.

It is the purpose of the writer in this article to review only the early American radium literature, the date at which it ceased to be really "early" having been arbitrarily fixed as January 1, 1906. The attempt will be made to give, first, a list of the books dealing entirely or in part with the subject named and adding a very brief review on each of them; second, an alphabetical list of all the articles that it has been possible to locate with comment on certain of the more interesting or important ones; third, a list of certain editorials appearing in medical journals, though this is farther from being complete than the first and second parts. It is sure that these lists are not complete although all the sources at the command of the writer have been searched. Corrections and additions will be much appreciated as it is my hope ultimately to compile as nearly complete a bibliography of the subject as is possible in both English and French. I believe that this article covers a field a little different than has hitherto been attempted. Although it is only a little over twenty years since radium began to be employed in medicine, the literature is already surprisingly extensive.

Because of the very remarkable physical properties of radium, and the fact that its discovery compelled the revision of previously existing notions regarding the composition of matter, the structure of the molecule and atom and the relation of electricity to matter, it is not surprising to find that physicists and physicians worked hand in hand in treating the earliest cases. Among the American physicists most worthy of mention are Dr. William Rollins of Boston, probably the first American to suggest radium as a therapeutic agent, William J. Hammer of New York, Professor Charles Baskerville, now of the College of the City of New York, Dr. George F. Kunz of New York, Professor P. G. Pegram of Columbia University and Professor John Trowbridge of Yale University. This list could be extended, but perhaps includes the American physicists most interested in the therapeutic possibilities of radium. While speaking of physicists it might be added that some of their very early prophecies have turned out to be most accurate. Further mention will be made of this in discussing some of their articles. At the same time a letter written by Alexander Graham Bell, inventor of the telephone, published in *American Medicine*, Philadelphia, August 15, 1903, p. 261, seems worthy of reproduction in full. It is as follows:

THE USES OF RADIUM

To the Editor of American Medicine:

It has occurred to me that perhaps you would care to publish the enclosed letter, and thus start some one experimenting with the radium rays in the manner suggested.

(Signed) Z. T. SOWERS.

Dear Dr. Sowers:

I understand from you that the roentgen rays and the rays emitted by radium have been found to have a marked curative effect upon external cancers, but that the effects upon deep seated cancers have not thus far proved satisfactory.

It has occurred to me that one reason for the unsatisfactory nature of these latter experiments arises from the fact that the rays have been applied externally, thus having to pass through healthy tissues of various depths in order to reach the cancerous matter.

The Crookes' tube, from which the roentgen rays are emitted is, of course, too bulky to be admitted into the middle of a massive

*Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6-7, 1921.

cancer, but there is no reason why a tiny fragment of radium sealed up in a fine glass tube should not be inserted into the very heart of a cancer, thus acting directly upon the diseased material. Would it not be worth while making experiments along this line?

(Signed) ALEXANDER GRAHAM BELL.

(REPLY)

Dear Mr. Bell:

The suggestion which you make in regard to the application of the radium rays to the substance of deep-seated cancer I regard as very valuable. If such experiments should be made I have no doubt they would prove successful in many cases in which we now have failures.

(Signed) Z. T. SOWERS, M.D.

The study of the early literature has some value other than its purely historical interest, as it gives the student a certain perspective that is difficult to obtain otherwise. It is needless to say that the gradual development of the present methods of technique is intensely interesting. In looking backward it may be seen that the early therapists developed a technique which is not so different from that of today, in a remarkably short space of time, even though the modern use of the emanation was not known.

It is rather strange in going over the list of early writers to find the names of but three men who are now members of the American Radium Society,—Dr. Robert Abbe, Dr. H. N. McCoy and Dr. Rollin H. Stevens,—although it is evident from the discussion of some of these early articles that certain other members were interested at this period, though they had themselves written nothing for publication.

It is interesting to note that several of the earliest references to radium in literature speak of the possibility of its use as an agent to take the place of the *x*-ray in the production of radiographs. Of course, this theory was soon dropped.

While it is a rather delicate subject to approach, I feel fairly sure that the following is a description of the first use of radium in this country as a therapeutic agent. It should be stated that what is here written is based almost entirely on what has been printed, backed by a certain amount of personal correspondence. Sometime during the year 1900 Dr. William Rollins of Boston, who had been previously much interested in the development of the *x*-ray, gave to Dr. Francis H. Williams, also of Boston, a small metal box with an aluminum front containing about 500 mgm. of a radium preparation of a strength of about 1000. Through the courtesy of Dr. Williams I am able to show you this identical package still intact. I think you will agree with me that it is of decided historical interest, as the use of this preparation by Dr. Williams was evidently the first employment of radium as a therapeutic agent in this country, and I feel that due credit should be given Dr. Rollins and Dr. Williams for their truly pioneer work. In fact, if positive proof of earlier work is not forthcoming, to these two men belongs the fame of being the earliest users in America.

Such proof as I have of this is as follows: The opening paragraph of a paper by Dr. Williams, which he states was written after consultation with Dr. Rollins, and was presented at the annual meeting of the Massachusetts Medical Society, June 9, 1908, says:

"In 1900 Dr. William Rollins of Boston suggested the use of the radiations from radium salts as a therapeutic agent and put capsules containing radium into my hands, but the salts then obtainable were not powerful enough to be efficient. But to Dr. Rollins is due the credit of being, so far as I am aware, the first to realize the probable value of these radiations as a therapeutic agent."

A personal communication from Dr. Williams in reference to this subject further states:

"I used this radium in rodent ulcer and lupus, but cannot give you a definite date as to my first use of it. It was too weak to compete with *x*-rays, although after some hours' application to the normal skin it caused a redness of the size of the capsule. In the summer of 1903 I went abroad and obtained 100 mgm. of pure radium bromide, and a large amount of radium of less radio-activity. On my return, I used the pure radium bromide with satisfactory results and started a radium clinic at the Boston City Hospital."

The following is a paragraph from an article entitled "Some of the Physical Properties and Medical Uses of Radium Salts; With Report of Forty-Two Cases Treated By Pure Radium Bromide", By Dr. Wil-

liams, which appeared in *The Medical News*, February 6, 1904:

"The first person, so far as I am aware, to appreciate that radium salts would probably be of service in the treatment of certain diseases was Dr. William Rollins, of Boston, who has done so much to promote the use of the *x*-rays. Between two and three years ago, Dr. Rollins put into my hands a metal box with an aluminum front, containing some chloride of radium, with the suggestion that I use it for therapeutic purposes. I did so employ it, but at that time the radium to be had was weak, and I did not obtain definite results."

It was undoubtedly true here, as has happened with other scientific discoveries that two or more investigators discovered the same fact or performed the same original experiment quite independent one of the others. The recognition of claims for early work is often made difficult by this fact.

The writer became interested in radium as a therapeutic agent in 1903 and treated his first case in November of that year, collaborating with his father, the late Dr. Walter B. Chase. It sounds rather strange at this time to state that the husband of the patient treated was willing to purchase the tube of radium salt that was used. The strength of this preparation was stated to be 7,000 (7,000 times the radio-active strength of uranium—the old method of measurement). This tube was purchased from the patient in January 1904 and a further supply of varying strengths was also obtained. One of these tubes when tested by modern methods in 1914 was found to contain but 50 micrograms, that is to say, .05 mgm. of radium element. In spite of the weakness of these preparations it is now possible to look back and note that certain results were obtained.

Strange as it may seem, radium literature is not without its humor, though it is usually the unconscious rather than the conscious form. In proof of this I am going to take the liberty of quoting literally two or three paragraphs of an article written in 1904.

"Radium is worth three times its weight in gold ($2,700,000 a pound).

"I believe that radium represents in its atoms the primordial elements of matter which God first charged with light, when He said, 'Let there be light.' In the aggregating of these elements to form the earth, radium was condensed from the rarified ultra-gouous state into solid masses, and with an immense amount of latent heat was packed away deep down in the mines of the earth. So soon as brought to the surface, and the pressure on its atoms lessened, the latter begin to disintegrate, and the internal heat is liberated. The particles at and near the surface rapidly fly off in every direction until the underlying more compact part is reached, the particles of which in their turn become gradually detached, and fly off in rapidly increasing quantities. Thus the atoms in one zone after another undergo disintegration with the liberation of energy.

"God *created* the primordial elements of matter before he *made* atoms, and molecules, and suns, and moons, and stars; and God created the primordial energy of motion before he made light, and heat, and electrictiy, and the other energies.

"In conclusion, I offer two theories explanatory of the action of radium:

"The first is that radium breaks up into infinitesimal particles, which are projected through the masses of other matter and divide them into fragments so minute that they readily pass through the walls of capillaries into the blood current, and are carried to the emunctories to be excreted. This is the mechanical theory. The second is that the cutting to pieces of the diseased masses by radium rays sets up an irritation to the tissues, causing afflux of blood and aggregation of leucocytes. The leucocytes pick up and carry off the divided masses. This is the vital theory.

"Radium shoots its myriads of fiery missiles through tumors, indurations, plastic deposits, etc., cuts them to pieces and renders them absorbable. It also shoots to death bacteria and protozoa by riddling them with its fast-flying projectiles and shattering them into a thousand fragments.

"This self-loaded and self-discharging engine of destruction keeps up its continuous but noiseless work with no appreciable evidence of exhaustion. Another remarkable fact is that the little projectiles sent out from radium, wherever they lodge, explode and scatter their fragments in all directions, dealing death and destruction to microbes."

However, despite an occasional lapse

such as this, the general average of the articles from the scientific standpoint is really very good. Following are the three lists comprising ten books, one hundred and twelve original articles and seventeen editorials.

BOOKS ON OR HAVING CHAPTERS ON RADIUM OR RADIUM THERAPY PRIOR TO 1906—AMERICAN

ALLEN, CHARLES WARRENNE, M.D., with the cooperation of Milton Franklin, M.D. and Samuel Stern, M.D. Radiotherapy and Phototherapy, Including Radium and High-Frequency Currents, Their Medical and Surgical Applications in Diagnosis and Treatment. Philadelphia, 1904.

This work on the subjects named includes a chapter of 31 pages entitled "Radio-Activity" in which radium and the other radio-active elements are discussed in a fairly comprehensive manner; although the writer says nothing of any personal work along this line.

BASKERVILLE, CHARLES, Ph. D., Radium and Radio-Active Substances; Their Application Especially to Medicine. Philadelphia, 1905.

This is a very concise treatise on the physics of radium, while one chapter, 27 pages, treats of "The physiological action of radio-active substances and their therapeutic applications." This gives an excellent summary of radium therapy up to 1905 and the accompanying bibliography is very good.

BECK, CARL, M.D. Roentgen Ray Diagnosis and Therapy. New York, 1904.

This book has a chapter of five pages entitled "Becquerel Rays and Radium," in which the subject is discussed very briefly.

CLEAVES, MARGARET A., M.D. Light Energy, its Physics, Physiological Action, and Therapeutic Applications. New York, 1904.

One chapter, 57 pages, is devoted to what was at that time a comparatively complete treatment of the subject of radium and radium therapy. It includes a fair bibliography of the subject.

COHEN, SOLOMON SOLIS, M.D. (Editor) System of Physiologic Therapeutics. Volume XI; Serotherapy, Organotherapy, Bloodletting, Radium, etc. Philadelphia, 1905.

This volume contains an article by Samuel G. Tracy, B.S. M.D., entitled "Radium, Thorium, and Radioactivity", which covers 33 pages and includes illustrations. The physics and the therapy of radium and the allied elements are very well discussed condidering the knowledge then available.

FREUND, LEOPOLD, M.D., Elements of General Radiotherapy for Practicioners, Translated by G. H. Lancashire, New York, 1904.

This is an English translation of a work published in Vienna, this English translation being printed in New York. It is a textbook on radiotherapy in general. One chapter, 15 pages, entitled "Becquerel-Rays," deals with the physics and therapeutics of radium.

HAMMER, WILLIAM J. Radium and other Radio-Active Substances; Polonium, Actinium, and Thorium, with a Consideration of Phosphorescent and Fluorescent Substances, the Properties and Applications of Selenium and the Treatment of Disease by the Ultra-Violet Light. New York, 1903.

A lecture delivered at a meeting of the American Institute of Electrical Engineers and the American Electrochemical Society, New York, April 17, 1903. The section of the book on radium takes up 31 pages, and deals almost entirely with its physics.

HAMPSOM, W., M.A. Radium Explained. A Popular Account of the Relations of Radium to the Material World, to Scientific Thought and to Human Life. New York, 1905.

This is an English work printed in Edinburgh, but bearing an American imprint. It is a popular account of the physics of radium and includes one chapter of 7 pages on "Radium and the Cure of Disease".

HIRSHBERG, LEONARD K., M.D. The Action of Light as a Therapeutic Agent. Providence, 1904. The Fiske Fund Dissertation XLVII.

This is a pamphlet, in which radium is discussed incidentally, the remarks on it covering 7 pages. It includes a very fair bibliography.

KING, WILLIAM HARVEY, M.D., LL.D. Static, High Frequency, Radio, Photo and Radium Therapy. New York, 1905.

This is a general treatise on the subjects stated. One chapter of 6 pages deals with the physics of radium and its emanation, while another chapter of 9 pages deals with the physiological action and therapeutics of radium.

LARKIN, EDGAR L. Radiant Energy. Los Angeles, Cal. 1903.

This is a rather popular work dealing with radiant energy—"radiant" here meaning, so the author states, "proceeding from a center in straight lines in every direction". The mention of radium and other radio-active elements is almost incidental.

ROLLINS, WILLIAM. Notes on *X*-Light. (Privately printed). Boston, Mass., 1904.

A beautiful volume, being a reprint of the various articles by the author appearing in many magazines, during 1896 to 1904, including four, dealing more or less directly with radium. Two of these articles are quite remarkable. One of them, "Radio-Active Substances in Therapeutics" (*Bost. M. & S. J.*, January 23, 1902), is perhaps the first American article dealing with radium as a therapeutic agent. It is short and of sufficient interest to quote in its entirety.

"During the year 1900 I made experiments with radio-active substances hoping to find a substitute for *x*-light. I found that some of the radiations retained their activity after passing through animal tissues as thick as the body of a guinea pig. I was so convinced of the value of radium that I placed about 500 mgm. in a sealed capsule to protect it from moisture, giving it to a physician with the request that it be tried on lupus, a disease which at that time was interesting him. The capsule was disk-shaped, with a front of aluminum, a back of comparatively nonradiable metal. I believe it to be important to test these substances in the treatment of lupus, superficial cancer, and diseases of the skin in which *x*-light has been found useful; therefore, I mention that I have another capsule which I shall be glad to send to any Boston physician who will give the matter a fair trial. Radio-active substances can be used in sealed capsules held against the body by adhesive plaster, or they can be made to cover larger areas by mixing them with rubber or celluloid to form moisture-proof plasters. These plasters may be still further protected by being coated on the sides nearest the body by aluminum foil and on the opposite sides by lead foil. They could be kept in stock by the yard by druggists and given to patients by prescription, with proper directions as to the length of application. They could be worn at night. Their use would prevent the poor from making such frequent visits to a physician as are now required when *x*-light obtained from a vacuum tube is used. This is a matter of some importance, as the present treatment takes many sittings which require time and cost money."

*Note added 1904: "Considering the present interest in radium, it may be worth while to say that no application was received for this capsule."

The other article entitled, "Some Principles Involved in the Therapeutic Applications of Radio-Activity" (*Bost. M. & S. J.*, November 12, 1903) states clearly certain principles, the value of which is only beginning to be appreciated today. The use of radium emanation in place of radium element is forecasted, and the question of applications made at a distance from the affected part is clearly discussed. He says, "In using the radio-active substances in disease of or near the skin, the depth of the diseased tissue to be affected must determine the distance of the radio-active substance from the surface of the patient, for the reason mentioned, namely, activity diminishes approximately as the square of the distance, though really more rapidly on account of the complex nature of the activity. If the radium is

placed ten centimeters from the skin, the intensity at a depth of one centimeter is nearly as great as at the surface for the more penetrating forms of activity. In many cases, therefore, the sound tissues below the diseased will be acted upon by a destructive agent whose activity would be nearly as great as at the place of disease.* The correct way in treating a skin disease with a radio-active substance is to consider to what depth it is desirable to confine as far as possible the activity. If to a slight depth, the radio-active substances should be almost in contact with the skin, the duration of the application being of proper length but always shorter than when at a greater distance. In this case healthy tissue at a depth of one centimeter would be acted on by radiations and emanation whose intensity would be less than one one-hundredth of those striking the skin; obviously a more scientific method."

This article further mentions what seem to be the earliest therapeutic experiments in this country—the treatment of lupus, and superficial cancers, with capsules of radium of a strength of 1000 (1000 times the strength of uranium) given to Dr. Francis H. Williams in the year 1900 and 1901.

ORIGINAL ARTICLES ON RADIUM AND RADIUM THERAPY PRIOR TO 1906—AMERICAN

ABBE, ROBERT, M.D. Radium and Radio-Activity. (*Yale M. J.*, June, 1904, Page 433.) The Subtle Power of Radium. (*Tr. Am. Surg. Ass.*, xxii, 253-262, also *Med. Rec.*, Aug. 27, 1904, 321-324).

Two excellent articles, illustrated, giving a number of careful case reports. In the second of these articles he states "It gives me pleasure to put on record such observations as I have been able to make during fifteen months with the best radium made by the laboratory of the Curies in Paris. I was able, by cabling a very early order, to get fifteen centigrams (2¼ grains) of the strength 300,000, which was part of the larger amount used by them in their experiments for calorimetric determinations (now historic). With this and other strong specimens obtained later, including one of German manufacture, denominated a million activity, I have been able to verify most of the interesting work of the foreign observers and to add some of my own." This proves that Dr. Abbe was one of the earliest original investigators in this country. Dr. W. W. Keen of Philadelphia discussed this paper and stated that he himself had treated 22 cases with radium.

*The alpha and beta rays having been filtered out.

ABBE, TRUMAN, A.B., M.D., Notes on the Physiologic and the Therapeutic Action of Radium. (*Wash. Med. Ann.*, January, 1904, p. 363-367).

A very good article including the report of a case of inoperable carcinoma of the cervix and vagina treated with radium, and also a very good bibliography.

ALLAN, S. J. Excited Radio-Activity Produced from Atmospheric Air. (*Proc. & Trans. Roy. Soc.*, Canada, Trans., 1902, ii, 71).

BALL, M. V., M.D., Radium; Its Possibilities in Medicine. (*Med. Fortnightly*, March 10, 1904, p. 149-151).

BARKER, G. F. Radio-activity and Chemistry. (*The Apoth. N. Eng. Drug.*, 1903, xv, 475-554-622).

BASKERVILLE, CHAS., Ph.D. Radium and Its Physiological Actions. (*Virginia M. Semi-month.* October 7, 1904, 298-299).

A brief article based on the chapter of his book dealing with the physiological action and therapeutics of radio-active substances.

BECK, JOSEPH C., M.D., Experiments with Radium in Some Nose, Throat and Ear Diseases. (*Laryngoscope*, December, 1904, 897-915, also *Chicago M. Rec.*, December 15, 1904, pp. 757-775).

A very good article with eleven extensive case reports and minor comment on other cases.

BECQUEREL, HENRI, D.C.L., Ph.D. On the Radio-activity of Matter. (*Rep. Smithson. Inst.*, 1902, p.197. Reprinted after revision from the *Scient. Am. Sup.*, June 7, 1902, No. 1379).

BOLTON, H. C. An Experimental Study of Radio-Active Substances. (*Rep. Smithson. Inst.*, 1898-9, pp. 155-162). A New Source of Heat; Radium. (*Pop. Sc. Month.* 1903, lxiii, 61-63).

BOLTWOOD, B. B. On the Radio-Activity of Natural Waters. (*Am. J. Sc.* 1904, xviii, 378). On the Ultimate Disintegration Products of the Radio-Active Elements. (*Am. J. Sc.*, 1905, xx, 253-267).

BRADBURY, R. H. Radium and Radio-Activity in General. (*Frankl. Inst.*, 1905, clix, 225-238).

BROKAW, A. V. L., M.D., Presentation of Specimen of Radium With Suggestions As to Its Therapeutic Value in Cancer and Other Malignant Diseases. (*St. Louis M. Rev.* December 12, 1903, pp.415-417).

BUMPSTEAD, H. A. Atmospheric Radio-Activity. (*Am. J. Sc.*, 1904, xviii, 1-11).

BUMPSTEAD, H. A. & WHEELER, L. P., Note On Radio-Active Gas in Surface Water, (*Am. J. Sc.*, 1903, xvi, 328). On the Properties of Radio-Active Gas Found in the Soil and Water Near New Haven (*Am. J. Sc.* 1904, xvii, 97-111.)

CAMP, E. T., M.D. Electric and Radiant Energy as Therapeutic Agents, (*Alabama M. J.*, June, 1905, pp. 356-369).

CLEAVES, MARGARET, M.D. Radium With a Preliminary Note on Radium Rays in the Treatment of Cancer, (*Med. Rec.* October 17, 1903, 601-606, also *J. Advanc. Therap.*, November, 1903, pp. 667-682).

The article of October 17th is, seemingly, the first which gives an actual report of a case treated with radium; that is to say, while other physicians undoubtedly treated cases at a much earlier date than this one (September 15, 1903), the history of this case was the first one published in America. This was a sarcoma of the left cheek. The same day a case of carcoma of the cervix was treated.

CURIE, P. Radium. (*Rep. Smithson. Inst.*, 1902-3, pp. 187-201).

DADOURIAN, H. M. Radio-Activity of Underground Air. (*Am. J. Sc.*, 1905, xix, 16-22).

DEARBORN, FREDERICK M., M.D. Radium Therapy in Skin Diseases (*N. Am. J. Homeop.*, November, 1905, 717-20).

DENNET, D. C., M.D. Radio-Therapy With Report of Cases. (*Med. Rec.*, February 13, 1904, 253-256).

DIEFFENBACH, WILLIAM H., M.D., A New Method For the Therapeutic Application of Radium Salt (*N. Am. J. Homeop.*, December, 1905, 769-774).

DRAKE, G. W., M.D. Radium Rays and Their Therapeutic Possibilities. (*Charlotte N.C. M. J.*, 1904, xxiv, 168-171).

DUNCAN, R. K., The Electric Theory of the Radio-Activity of Matter, etc. (*New Knowledge*, 1905, also *New York Herald*, August 6, 1905).

EINHORN, MAX., M.D. Radium Receptacles For The Stomach, Esophagus, and Rectum, (*Med. Rec.*, March 5, 1904, p. 399).

A brief article illustrating and describing the author's radium capsule, which was at-attached to a thread and swallowed by the patient having cancer of the stomach. A bougie to which a radium capsule is screwed is also described for use in cases of cancer of the esophagus and rectum. The capsule contained 250 mgm. of 7,000 activity radium. Bougies of a similar style are used today for esophagus cases.

Observations on Radium. (*Med. Rec.*, July 30, 1904, pp. 164-168).

This article describes the author's method of the transillumination of various organs with radium. Among other things he was able to determine the position of the greater curvature of the stomach. Several cases of esophageal cancer treated by radium are reported.

FREUDENTHAL, W., M.D. The Effect of The Rays of Radium Upon The Mucous Membrane of The Larynx. (*Arch. Electrol. Radiol*, 1905, iv, 318-320).

A preliminary report of a case of laryngeal tuberculosis treated by radium.

GAGER, CHARLES STUART, Ph.D., Preliminary Note on the Effects of Radium Rays on Plants. (*Am. Med.*, ix, 1905, p. 1026).

Preliminary Notes on the Effects of Radio-Activity on Plants, (*Science*, 1905, n.s. xxii, 118).

GIES, WILLIAM J., Studies of the Effects of Radium with Demonstration. (*Proc. Soc. Exper. Biol. & Med.*, 1904-5, ii, 86).

HAMMER, WILLIAM J., Radium, Polonium and Actinium; (*Scient. Am. Sup.*, February 28, 1903, 22710-22711).

A very good popular account of the physics of radium and the allied radio-active elements.

HODGSON, FRED G., M.D., Radium; A Review of the literature. (*N. York. M. J.*, January 14, 1905, pp. 62-65).

An article that is satisfactory as far as it goes, but as it only gives some seventeen or eighteen references, is far from complete.

INGLIS, JOHN, A.M., M.D. Radium and Radiant Energy. (*J. Am. M. Assn.*, February 6, 1904, pp. 370-373).

KANOLT, C. W. Radium, Its Extraordinary Properties. (*Scient. Am.*, February 28, 1903, p. 149.)

A brief but concise article on the physics of radium.

KING, WILLIAM HARVEY, M.D., LL.D. Radium and Its Use in Medicine. (*N. Am. J. Homeop.*, December, 1903, pp. 729-733.)

One of the earliest articles. He reports a case of neuritis of the right optic nerve treated by him in 1903. He also speaks of the work of Mr. W. J. Hammer. The article ends with the following prophecy: "The professional world is alive to the great possibilities there are in radium, and I venture to predict that within a very few years it will occupy an important, yet limited, and unique position in therapeutics."

KROPATKIN, PRINCE., Unsuspected Radiations. (*Rep. Smithson. Inst.*, 1899-1900, pp. 371-385).

KUNZ, GEORGE F. Radium. (*American Review of Reviews*, November, 1903).

An excellent popular article on the subject.

KUNZ, GEORGE F., and BASKERVILLE, CHARLES. The Action of Radium, Roentgen-Rays and Ultra-Violet Light on Minerals and Gems. (*Science*, 1903, n. s. xviii, 769-783).

An important scientific article on the subject named.

LIEBER, HUGO, Radium und Radio-Aktive Stoffe und Deren Verwendung in der Medizin. (*N. Yorker Med. Monatschr.*, 1904, xvi, 49-58. Discussion 253-256). Radium and Some Methods for Its Therapeutic Application, With Demonstrations (*Proc. Soc. Exper. Biol. Med.*, 1904-5, ii, 32-37. Also *Med. News*, 1905, lxxxvi, 229-231, also *Am. Med.*, January 14, 1905, p. 72).

LLOYD, JOHN URI, Phar. M. Radiant Energy, (*Eclect. M. J.*, November, 1903, 583. Also *Cincin. Lancet-Clinic*, December 5, 1903, p. 595).

McCOY, H. N. Radio-Activity as an Atomic Property. (*J. Am. Chem. Soc.*, 1905, xxvii, 391-403).

McLENNAN, J. C., and BURTON, E. F. On the Radio-Activity of Metal Generally. (*Univ. Toronto, Stud. Phys. Sc.*, 1903, pp. 27-32).

MERZ, C. H. The Physics and Therapy of Radium. (*Electro-Therap.*, 1904, viii, 80-87).

METZENBAUM, MYRON, B.S., M.D. Radium, Radio-Active Substances and Aluminum with Experimental Research of the Same. (*Cleveland M. J.*, May, 1904, pp. 191-208).

A rather long article giving the details of a number of original experiments on the physics of radium and the allied elements and also reporting a case of lupus treated with radium.

Radium, Its Value in the Treatment of Lupus, Rodent Ulcer, and Epithelioma, With Reports of Cases. (*Internat. Clin.*, 1905, iv, 21-31. With 6 plates).

Radium; Its Value in Medicine. (*Cincin. Lancet-Clinic*, May 13, 1905, pp. 555-557. Also *Canad. Pract. & Rev.*, October, 1905, pp. 548-551. Also *Louisville Month. J. M. & S.*, November, 1904, pp.188-190).

This article includes the report of six cases of rodent ulcer, lupus and superficial epitheloma, all successfully treated with radium.

MEYER, G. M. The Radio-Activity of the Different Organs after the Intravenous Injection of Radium Bromid (Abstract). (*Am. Med.*, 1905, ix, 1030).

MILLIKAN, R. A. Recent Discoveries in Radiation and Their Significance. (*Pop. Sc. Month.*, April, 1904, pp. 481-499).

MOFFET, CLEVELAND. The Wonders of Radium. (*McClure's Mag.*, November, 1903, p. 1).
Sense and Nonsense About Radium (*Success*, April, 1904).

MORTON, WILLIAM JAMES, M.D. Treatment of Cancer by the *X-Ray*, with Remarks on the Use of Radium. (*Internat. J. Surg.*, October, 1903, pp. 289-294).

PARKHURST, BURLEIGH, M.D. Therapeutic Experiments with Radium. (*Pacific Coast J. Homeop.*, 1904, xii, 137-142).
Radium Therapy, Experiences and Suggestion. (*Tr. Am. Inst. Homeop.*, Chicago, 1905,lxi, 792-795. Also *N. A. J. Homeop.*, November, 1905, pp. 713-717).

PARTRIDGE, E. A., and BRADBURY, R. H. Radio-Activity, (*J. Frank. Inst.*, 1903, clvi, 1596-1599).

PEGRAM, G. B. Detection and Measurement of Radio-Activity. (*Arch. Electrol. & Radiol.*, 1904, iv, 313-317).

An excellent scientific article and one of the earliest dealing with the subject named.

PHILIPS, W. C. Experiences With Radium Emanations. (*Med. News*, 1905, lxxxxvii, 341-343).

PIFFARD, HENRY G., M.D., LL.D. Radio-Praxis. (*Med. Rec.* March 7, 1903, 361-366).
Radium, the First Wonderful Discovery of the New Century. Its Identity, Discovery, Properties, Effects upon Living Tissue, Probable Therapeutic Uses and Magnificent Possibilities. (*Med. Council,* December, 1903, pp. 405-408; January, 1904, pp. 1-4).

A very good popular article. It is unsigned but is attributed to Dr. Piffard by the index of the Surgeon General's Library.

A Few Words Concerning Radium. (*Med. Rec.*, June 18, 1904, pp. 999-1004).

A good article, which is, as he states, "an outline of the principal facts that have been ascertained concerning radium".

PRESCOTT, S. C. The Effect of Radium Rays on the Colon Bacillus, the Diphtheria Bacillus and Yeast. (*Science*, 1904, n. s., xx, 264).

PUSEY, WILLIAM ALLEN, A.M., M.D. Radium and its Therapeutic Possibilities. (*J. Am. M. Assn.,* July 16, 1904, pp.173-180, with discussion).

A well-written and conservative paper read before the fifty-fifth annual session of

the American Medical Association. It sums up very well the facts known at the time. The discussion is also interesting.

RAMSAY, SIR WILLIAM. Radium and Its Products. (*Harpers Monthly Mag.*, N. Y., 1904, cx, 52-57).

RAMSAY, SIR WILLIAM and SODDY, F. Experiments in Radio-Activity and the Production of Helium with Radium. (*Rep. Smithson. Inst.*, 1902-3, pp. 203-206).

ROBARTS, HEBER, M.D., M.E. Radium (*Am. J. Surg. & Gynec.*, March, 1904, pp. 145-148, and April, 1904, pp. 153-156).

Radium. (*Dental Brief*, 1904, ix, 409-418; Also *Med. Fortnightly*, May 10, 1904, pp. 279-284. With one illustration).

ROCKWELL, A. D., A.M., M.D. Radio-Activity. (*Arch. Physiol. Therapy*, March, 1905, i, 65-68).

ROLLINS, WILLIAM. The Cathode Stream and *X*-Light, (*Am. J. Sc.*, November, 1900, 383-391).
Notes on *X*-Light: Radio-Active Sub-Stances in Therapeutics (*Boston M. & S. J.*, January 23, 1902, 85).
Some Principles Involved in the Therapeutic Applications of Radio-Activity (*Boston M. & S. J.*, November 12, 1903, pp. 542-544).

On Passing The Beta Radium Rays Through a Strongly Charged Aluminum Plate. (*Elect. Rev.* January 9, 1904).

The second and third of these articles are reviewed at length in the part devoted to books. The first article mentioned, published in November, 1900, mentions experiments on human tissues, with radio-active substances and comments on the possibility of their being used in medicine.

RUDIS-JICINSKY, J., M.D., A.M., M.E. Experimental Investigations with Radium Upon Living Tissues. (*Iowa M. J.*, April 15, 1904, pp. 141-143).
Radium, a Name Only. (*Am. X-Ray J.*, April 15, 1904, pp. 102-104).
The Dosage in the Treatment With Radium. (*Iowa M. J.*, September 15, 1904, pp. 344-346).
Radium in Surgery. (*Arch. Physiol. Therapy*, March, 1905, pp. 74 to 77).

The first of these articles gives the results of certain experiments on guinea pigs and rabbits with the microscopical findings of the tissue exposed to radium.

The third article reports a case of mammary carcinoma treated with radium unsuccessfully. Only fifty mgm. of 7,000 activity were used.

RUTHERFORD, ERNEST, D. Sc., Ph.D., LL.D. F. R. S. The Existence of Bodies Smaller than Atoms. (*Proc. & Trans. Roy. Soc. Can.*, 1902, ii, 79).
Excited Radio-Activity and Ionization of Atmospheric Air. (*Bull. Am. Phys. Soc.*, 1902, ii, 59).
Radium. (*Montreal M. J.*, February, 1904, pp. 112-116).
Present Problems in Radio-Activity. (*Pop. Sc. Month.*, May, 1905, pp. 5-34).

The third of these articles, being an abstract of a lecture with experiments delivered before the Montreal Medico-Chirurgical Society, January 8, 1904, gives a very concise summary of the physics of radium and warns agains its careless use as a therapeutic agent.

SABINE, WALLACE C., A.M. The Physical Relationship of Finsen Light, Roentgen-Rays and Radio-Activity. (*Med. Communicat. Mass. M. Soc.*, 1904, xix, 645-655. Also *Boston M. & S. J.*, August 11, 1904, 159-161).

An excellent scientific article on the subject named.

SHIELDS, PERCY, M.D. *X*-Ray Phenomena and Phenomena Not Due to *X-Rays* (*Cincin. Lancet-Clinic,* April 11, 1903, pp. 371-377).

SHIELDS, EDWARD H., M.D. For What Conditions and How Should *X-R*ays Be Used? (*Cincin. Lancet-Clinic,* April 11, 1903, pp. 377-382.)

These two articles form practically one and mention radium incidentally.

SICKLES, WILLIAM, M.D. Radio-Activity. The Therapeutic Result We May Expect at its Present Stage of Development. (*Wisconsin M. J.*, April, 1905, pp. 623-627).

A good article dealing largely with the physics of radium and warning against so-called radium therapy with preparations having an activity of 200 or 300 and stating quite truly that no conclusions can be drawn from such treatments.

SOUTHWICK, GEORGE R., M.D. Radio-Activity. (*N. Eng. M. Gaz.*, November, 1904, pp. 496-505).

STAPLER, D. A. Radium. (*Occidental M. Times*, 1904, xviii, 49-52).

STEVENS, ROLLIN H., M.D. Clinical Experience With Radium. (*University Homeopathic Observer, Univ. of Mich.*, January, 1904).
Further Clinical Experiences with Radium with the Special Reference to Leiber's Radium Coatings. (*Trans. Am. Inst. Homeop.*, 1905, lxi, 796-800. Also *N. Am. J. Homeop.*, November, 1905, pp. 720-725).

These articles give Dr. Stevens' personal experiences with the use of radium and comment favorably on Leiber's radium coatings as a method of application.

STEWART, R. M. On Excited Radio-Activity. (*Proc. & Trans. Roy. Soc. Can.* 1902, p. 71).

STORCK, J. A. Some Facts Concerning Radium and the Use of the Intragastric Radiode. (*Am. Med.*, 1904, vii, 820-822. Abstr. *N. Orl. M. & S. J.* May, 1904, pp. 851-852).

STOVER, G. H., M.D. Radium. (*Colorado Med.*, January, 1904, pp. 92-97).

An article dealing with the physics of radium and mentioning some of the author's experiments as well as giving three case reports.

SULLIVAN, J. C., M.D. Radio-Activity. (*Illinois M. J.*, August, 1904, pp. 236-238).

TAYLOR, W. H. Radium, Its Radiations, Physical, Chemical & Mental. (*Old Dominion J. M. & S.*, Richmond, 1904-5, iii, 417-438).

THOMSON, J. J. On Bodies Smaller than Atoms. (*Pop. Sc. Month.*, 59, 1901, 323. *Ann. Rep. Smithson. Inst.*, 1901, p. 231, 1902).

TRACY, SAMUEL G., B.S., M.D. Radium in Medicine. (*N. York. M. J.*, October 24, 1903, pp. 792-794).
Radium. (*J. Advanc. Therap.*, December, 1903, pp. 758-767).
Radium: Induced Radio-Activity and its Therapeutical Possibilities. (*N. York M. J.*, January 9, 1904, pp. 49-52).
Thorium: A Radio-Active Substance with Therapeutical Possibilities (*Med. Rec.*, Jan. 23, 1904, pp. 126-128).
Radium. (*Med. Brief*, 1904, xxxii, 43-48).

Dr. Tracy was among the earliest experimenters and users of radium and the allied elements. His series of articles is of decided interest. Also note the review of the book, "System of Physiologic Therapeutics", Volume XI, edited by Cohen.

TROWBRIDGE, JOHN, S.D. Recent Advance in Physical Science. (*Internat. Month.*, January, 1900, pp. 123-132).

A very important early article on the *x*-rays and radio-active substances, etc., which mentions the possibility of the use of radio-activity as a therapeutic agent.

TROWBRIDGE, JOHN, S.D. and ROLLINS, WILLIAM. Radium and the Electron Theory. (*Am. Jour. Sci.*, 1904, n.s., xviii, 77-79).

VAN BUREN, F., Jr. and ZINSSER, H. Some Experiments with Radium on Bacteria. (*Am. Med.* 1903, vi, 1021).

This article is one of the earliest dealing with the action of radium on bacteria.

WALLIAN, SAMUEL S., A.M., M.D., Radio-Activity in Diabetes and Nephritis. (*St. Louis M. Rev.*, August 26, 1905, pp. 179-180).

This article mentions the fact that the therapeutic value of the water from certain famous springs is evidently due to its radio-activity.

WATTIEZ, CY. Radium, its Recent Development. (*Scient. Am. Suppl.*, No. 1438, 1903).

WIGHT, J. S. Recent Researches in Radio-Activity and Electricity. (*Am. Med.*, March 5, 1904).

WILLIAMS, FRANCIS H., M.D. Note on the Use of the Fluorometer to Estimate the Proportions of Beta and Gamma Rays Given off from Radium Salts. (*Boston M. & S. J.*, December 17, 1903, p. 691).

Some of the Physical Properties and Medical Uses of Radium Salt, with a Report of Forty-Two Cases Treated by Pure Radium Bromide (*Med. News*, 1904, lxxxiv, 241-246).

A Comparison between the Medical Uses of the *X-Rays* and the Rays From the Salts of Radium (*Boston M. & S. J.*, February 25, 1904, pp. 206-209).

Notes on Radium. Production of the Gamma Rays from the Beta Rays of Radium; Use of Radium in Some Diseases of the Eye (*Boston M. & S. J.*, May 26, 1904, pp. 559-561).

Dr. Williams' work with radium as a therapeutic agent, seemingly the earliest in this country, has been commented on in the body of my article. The second and third of these four papers are particularly valuable from the scientific as well as the historical standpoint. The technique of the applications is especially interesting.

WINKLER, CLEMENS. Radio-Activity and Matter (*Pop. Sc. Month.*, 1905, p. 267).

EDITORIALS ON RADIUM AND RADIUM THERAPY PRIOR TO 1906—AMERICAN

The Future of the *X*-Rays. (*J. Am. M. Assn.*, January 13, 1900, p. 115).

Comment on Professor Trowbridge's article in the *International Monthly* for January, 1900. It mentions the possibility of radio-active substances being employed in place of *x*-rays to make radiographs. It states that there are other scientific possibilities and ends by saying, "no one can tell, nevertheless, what new possibilities may exist even in this particular direction, in the near future."

The Radium Rays in Therapeutics. (*J. Am. Assn.*, October 4, 1902, p. 846).

This mentions the work of some of the early French radium therapists—Danlos, Hallopeau and Gadaud.

Radium in the Treatment of Lupus. (*N. York M. J.*, April 25, 1903, p. 754).

Mentions the work of the same three French experimenters named above.

Remarkable Properties of Radium. (*J. Am. M. Assn.*, May 9, 1903, pp. 1293-1294).

Radium and Cancer. (*J. Am. M. Assn.*, July 11, 1903, pp. 107-108).

Mentions the report of a case treated by Professor Gusenbauer of Vienna.

Further Observations in Regard to Radium. (*J. Am. M. Assn.*, August 1, 1903, p. 317).

Mentions further experiments by French and Austrian scientists.

A Radium Calculation. (*J. Am. M. Assn.*, August 8, 1903, pp. 376-377).

Mentions an article in the English periodical "Nature", in which it is calculated that 3.6 grams in each cubic meter of the sun's bulk would be all that is required to account for the radiation. It also says, "An ounce, or

even a gram of radium might be an awkward thing to handle, and the isolation of a larger quantity be a positive danger to the community."

Radium. (*Med. Rev. of Rev.*, August 25, 1903, pp. 730-731).

Considers the physics of radium and mentions the possibility of its use ultimately in medicine.

Radium as a Therapeutic Agent. (*Med. Rec.*, October 24, 1903, p. 660).

Considers the physics of radium and ends by saying, "There is a possibility, perhaps almost a likelihood, that it may eventually become of inestimable value in medicine, but at present, sufficient is not known of its properties to pass a decided opinion. It is in its potential stage, but may emerge now at any time into an actual medical remedy of surpassing merit."

Radio-Activity and Radio-Therapy. (*Dietet. & Hyg. Gaz.*, November, 1903, p. 670).

The Therapeutic Possibilities of Radium. (*Boston M. & S. J.*, November 5, 1903, pp. 524-525).

An excellent summary of the then-current knowledge of radium and radium therapy.

Therapeutic Uses of Radium. (*St. Louis Med. Rev.*, December 19, 1903, pp. 437-438).

Mentions the possibilities of radium therapy and ends by saying, "Considering these facts, the ease at which radium rays may be applied to regions hardly accessible to the *x*-ray, and the faculty which radium possesses of imparting its properties to common substances, it would seem probable that the new metal will prove of wide-spread and practical value."

The Surgical Uses of Radium. (*J. Am. M. Assn.*, March 26, 1904, p. 832).

Discusses Dr. Truman Abbe's paper in the Washington Medical Annals, January, 1904. M. and Mme. Curie, the Discoverers of Radium. (*N. Eng. Med. Gaz.*, October, 1904, pp. 465-466).

A humorous editorial based on an article in the *British Homeopathic Monthly Review*, which stated, "Although M. and Mme. Curie are entirely absorbed in their laboratory work and do not concern themselves with medicine, we are able to state with some amount of pride, that both the father and grandfather of the former were homeopathic physicians."

The Action of Radium on Cancer (*J. Am. M. Assn.*, December 10, 1904, p. 1794).

Common Sense and Radium. (*M. Rec.*, May 14, 1904, p. 780).

A Forecast of Radium in Fiction. (*Med. Rec.*, April 9, 1904, pp. 580-581).

DISCUSSION

Dr. W. S. Newcomet. When I was called upon to discuss this paper I hardly knew at what angle it would be taken up. It appeared to me at first thought, that about 1906, most papers on this subject were either so scientific that most of us could not understand them, or else they were ordinary newspaper articles. However, some interesting articles were published. In 1903 Hemmer called attention to the fact that Professor Curie had recognized Colorado was rich in radium. He also, on page 20, gives this rather remarkable statement, that a French Company expected to produce nearly pure radium at $6,000 a gram! That is one fact that has not materialized, and there evidently was some slight miscalculation. It seems strange, too, that books published to 1906 on *x*-rays had several pages devoted to radium and the use of emanation as an inhalation for the cure of tuberculosis.

It is also interesting to see how conditions have changed, in the names which were adopted for the various applicators. If we review the early work of Abbe and Williams we find many of their suggestions are being used at the present time. In 1905 we find that Abbe reported his work on goiter. Dr. Williams, many of us remember, was one of the first to give us something of value. The American physicians had many other early works in this field which certainly have added credit to the whole profession.

PRELIMINARY REPORT ON A NEW TUBE FOR PRODUCING DUODENAL BLOCK

By ROSCOE G. VAN NUYS, M.D.

OAKLAND, CALIFORNIA

IN gastrointestinal work it has often occurred to me that it was easier to diagnose pathology in the stomach than in the duodenum, for the reason that the pylorus blocks for a time the passage of the opaque medium from the stomach. In the duodenum, on the other hand, there is nothing to block the barium suspension while the contour is being visualized.

I expressed this dissatisfaction to one of my surgical colleagues, Dr. Dexter M. Richards, and he suggested making an artificial block. This I set out to accomplish. At first we used an ordinary Rehfuss tube about which we had securely tied a tip of a finger cot. This was allowed to enter the duodenum in the usual way. A barium meal was then given by having the patient swallow the mixture. A Leur syringe was then attached and a barrel of air was injected which distended the finger cot. Under the fluoroscope the barium could then be expressed by digital pressure from the stomach and the duodenum filled proximal to the distended finger cot. This we felt would be of distinct value in the diagnosis of duodenal ulcer, diverticulum, dilated duodenum, adhesion, etc.

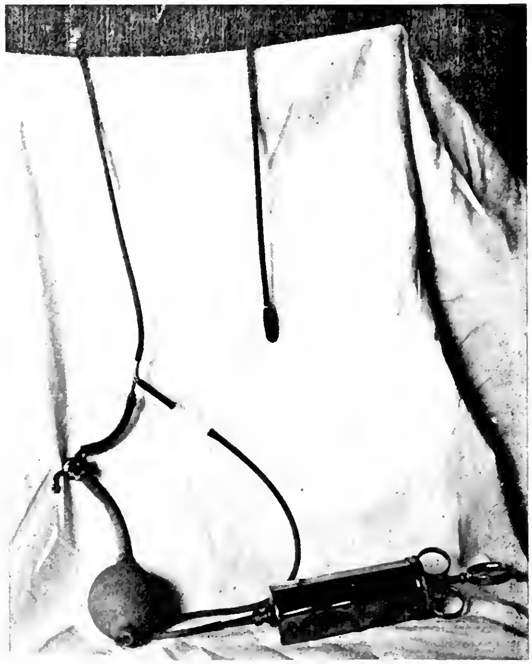

FIG. 2.

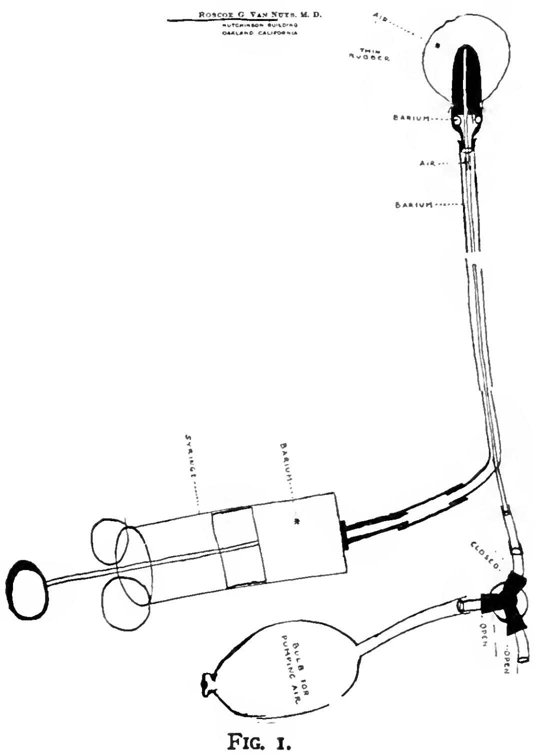

FIG. 1.

I felt, however, that a more useful tube might be devised. The principle of it is a tube within a tube. In other words, air can be pumped by a rubber bulb through a very fine tubing into the rubber tip and retained there by turning a three-way-cock. Behind this distended finger cot the larger outer tube terminates in holes through which the barium suspension can be forced by a large syringe, as can readily be seen in the following diagram.

We used the tube on several normals first of all and later on a few pathological cases. The number of these should be increased before reporting.

In the normal we find some incompetence

of the pylorus; some of the barium runs back into the stomach. With the fluoroscope in a thin individual it is interesting to watch the peristalsis of the duodenum outlined by the barium in the folds of the rugae against the bag of roentgenolucent air.

We also noted that in one case where we had distended the block a little more than usual, the patient, a nurse, complained of a heavy feeling which persisted for twenty-four hours. After removing the tube from this same patient we noted with the fluoroscope that the bowel seemed less active in passing the barium along. The advantages that we hope to realize are:

1. Better filling of the duodenum for the purpose of diagnosing ulcer, diverticulum, adhesions, tumor masses, etc.

2. Combination of gastric analysis and duodenal analysis with the roentgen examination so that a tube will have to be swallowed only once.

3. Examination of the duodenum throughout the entire length without the disadvantage of having the third portion covered by the shadow of the barium-filled stomach.

4. Magnesium sulphate, or other therapeutic and diagnostic agents, may be more effectively administered and retained in place.

5. While yet in the stomach a little air in the tip causes it to float to the surface if there is any hypersecretion. This quickly gives the level of the fluid.

6. The tube as constructed has a smaller tip than the Rehfuss or other duodenal tubes, and can be more readily pressed through the pylorus by digital pressure guided by the fluoroscope.

A SIMPLE DEVICE TO PREVENT THE OMISSION OF FILTERS IN DEEP ROENTGEN THERAPY*

By GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

As the thickness and density of filters are increased, and with the increase in the potential energy used in deep roentgenotherapy, the dangers incident to the omission of the filter have correspondingly increased. No arguments will be needed to indicate the dangers of such omission. Ultimately we shall probably utilize separate outfits for deep roentgenotherapy distinctive from those used for superficial therapy, but comparatively few laboratories have reached a stage in which this is practical; and until that stage is reached corresponding caution must be used.

A simple device toward this end, though still not foolproof, consists in the attachment of a piece of red silk ribbon to the edge of the opening in the tube holder or shield, and above the point of insertion of the filters. This should be of sufficient length to permit it to drop through the opening provided no filter is in place to hold it up. The ribbon can be weighted by a small piece of aluminum or asbestos which will force it to drop quickly if not held up by the filter.

This same device can be used to indicate the omission of subsequent filters. For instance: if one at times uses 2 mm. of filter and at others 6, the 2 mm. filter can have attached to its bottom a green ribbon in like manner, so that when the subsequent and additional 4 mm. of aluminum are not inserted, the green ribbon will hang downward and indicate that only 2 mm. are in place. Since all of us keep our eyes on the patient and the tube outfit during the exposure, only a second or two could pass before this signal would be noticed.

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D.C., Sept. 27-30, 1921.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

H. M. Imboden, M.D., *Editor* · Paul B. Hoeber, *Publisher*

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

THIRD ANNUAL MEETING
EASTERN SECTION, THE AMERICAN ROENTGEN RAY SOCIETY
ATLANTIC CITY, N. J., JANUARY 26, 27, 28, 1922.
Headquarters, Meetings and Exhibits, Ritz-Carlton Hotel

RADIODERMATITIS

There is probably no subject of greater interest and importance to the roentgenologists today than that of radiodermatitis. More and more actual, supposed or alleged cases of radiodermatitis are developing throughout the country. For the sake of the advancement of our science, for the protection of the roentgenologists, and for the good of the public, it is most important that every possible precaution be taken to prevent this condition. We should also prevent the patients and their friends from assuming that any unfortunate result, of whatever nature, that develops in the course of treatment or examination of a patient, is due to the application of the rays.

Toward this end it is clearly our duty to use every possible precaution against the production of any dermatitis, excepting where it is definitely indicated. Likewise a careful study should be made of the principles governing roentgenization, namely the careful measurement of time by a timing clock, the careful measurement of distance by a rule or some other definite measuring instrument, without guessing at the distance. We must bear in mind that the rays decrease in intensity proportionate to the square of the distance and increase according to the square of the distance when the focal skin distance is *decreased*. The radiation value increases approximately according to the square of the voltage. Further we should be most careful as to the milliampereage and filtration, and be sure that we are actually using what is intended. It is most important that detailed and complete records be kept of what is done.

Any device that can be developed which will help to prevent the omission of a filter in therapeutics will be useful. The danger-ribbon previously described is one step in this direction. The electrical device shown by one of the exhibitors is another. The devices described by Driessen[1] and by Holzknecht[2] are further steps in the proper direction. Careful attention given to the patients to prevent the application of any irritants to the skin following roentgenization will go far towards eliminating some of the disagreeable experiences that all roentgenologists have.

Next it is very important that the term "*x*-ray burn" be eliminated from our vocabulary. It is incorrect. It is in no sense a burn. There is no heat applied, and the sooner we cease the use of this word the better it will be for both patients and operators. Therefore, one should never speak to a patient or to any of his friends, or even to other roentgenologists, of a "burn" or refer to any irritation of the skin as a "burn." The practicioners of medicine should be discouraged from referring to any irritation of the skin that develops in the course of the examination or treatment as a "burn," no matter how mild or how unimportant. It is practically impossible, without the history of exposure to roentgenization and without the elimination of other causes, to state that the irritation of the skin is due to roentgenization, no matter in what stage it is found, and in all other instances other possibilities should be considered by the consultants.

[1]Driessen. *Zentralbl. f. Gynäk.*, October 30, 1920, xliv, 1258.

[2]Holzknecht. *Münch. med. Wchnschr.*, February 20, 1920, 213.

Finally, the expert roentgenologist, for the good of roentgenologists and for the good of patients in general, should be most cautious about drawing conclusions as to neglect or incompetence, for great harm can be done to the progress of the science by the multiplication of lawsuits. Great injustice can be done to the roentgenologist who is falsely accused, for even though he is proven innocent he is put through a nervous strain and to the expenditure of time and money for which there is no recompense, and ultimately the very evidence that the expert uses he may find standing against him when some patient of his has had an unfortunate end result, even though this is no fault of the roentgenologist himself.

G. T. Pfahler

PRELIMINARY PROGRAM OF MID-WINTER MEETING EASTERN SECTION A. R. R. S.

Thursday, Jan. 26, 8:15 p.m.

Address: Joseph A. Blake, M.D., New York.
Tumors of the Chest. L. Jaches, M.D. and H. Wessler, M.D., New York.
A Review of the X-Ray Diagnosis of Lesions of the Esophagus. Wm. H. Stewart, M.D., New York.
Standardization of X-Ray Reports. P. M. Hickey, M.D., Detroit.

friday, 9 a.m.

A Preliminary Report on some Experimental Work with Therapy of the Tonsils and Adenoids. C. A. Waters, M.D., and S. Crowe, M.D., Baltimore.
Injection of Normal and Obstructed Tear Sacs. H. P. Doub, M.D., Detroit.
Congenital Syphilis as shown in X-Ray Plates. R. N. Pierson, M.D., New York.
A Discussion of Abnormalities in the Sella Turcica. Walter Timme, M.D., New York.
The Report of the Committee of Safety on Electrical Dangers. Prof. John S. Shearer, Chairman, Ithaca, N. Y.

Friday, 2 p.m.

The Interpretation of Bone Plates; The Differential Diagnosis of Tuberculosis, Syphilis and Osteomyelitis. Robert W. Lovett, M.D., Boston.
Abnormal Pulmonary Densities as an Aid in the Prognosis of Pulmonary Tuberculosis. Kennon Dunham, M.D., Cincinnati.
Foreign Bodies in the Esophagus. Willis F. Manges, M.D., Philadelphia.

Symposium on Education
Graduate Teaching. G. W. Holmes, M.D., Boston; L. Jaches, M.D., New York; Prof. J. S. Shearer, Ithaca, N. Y.
Undergraduate Teaching. Frederick H. Baetjer, M.D., Baltimore, and Henry K. Pancoast, M.D., Philadelphia.

Friday, 8:15 p.m.

Address: Lewellys F. Barker, M.D., Baltimore.
The Annual Exhibit of Lantern Slides. [Those desiring to show slides should notify either the President or the Secretary of the Section.]

saturday, 9 A. M.

Some High Voltage Problems. Frank Rieber, San Francisco.
The Organization of a Therapeutic Department. Harvey Gaylord, M.D., Buffalo.
A Résumé of the Physical Factors Concerned in Deep Therapy. Prof. John S. Shearer, Ithaca, N. Y.
Title to be Announced. Prof. Wm. Duane, Boston.
Biological Dosage. Francis Carter Wood, M.D., New York.
Topic to be Announced. Curtis F. Burnham, M. D., Baltimore.
Topic to be Announced. James T. Case, M.D., Battle Creek.

Saturday, 2 p.m.

Business Session.
A Practical Demonstration of Treatment Methods:
Therapy of Brain Tumors. Henry K. Pancoast, M.D., Philadelphia.
Therapy of the Thyroid Gland. G. W. Holmes, M.D., Boston.
Therapy of the Mammary Glands. George E. Pfahler, M.D., Philadelphia.
Therapy of the Tonsils and Adenoids. W. D. Witherbee, M.D., New York.

Saturday, 8 p.m.

Dinner; Dance.

Complete programs will be sent to members of the American Roentgen Ray Society, and to others upon request.

CORRESPONDENCE

226 Michigan Street, Toledo, Ohio.

To the Editor:

During my absence in Europe there was sent to my office a number of copies of the old *American Quarterly of Roentgenology*. These were opened and the wrapper mislaid, so I was unable to trace the donor and consequently cannot acknowledge receipt of these valuable copies. Volume 1 of the *Quarterly* is especially valuable. I trust that the sender will communicate with me so that I may make proper acknowledgment.

H. W. Dachtler
Librarian.

To the Editor:

I beg to report herewith the proceedings of the Second Annual Meeting of the Canadian Radiological Society, which was held in conjunction with the Ontario Radiological Society at Niagara Falls, from May 31st to June 2nd, after which we adjourned and went to Boston, where the meeting was reconvened with the North American Radiological Society meeting on the 3rd and 4th of June.

The attendance at the meeting was far in excess of our most sanguine expectations. The program, which was contributed to mainly by members of our own Society, also included valuable contributions from Dr. A. E. Barclay, Manchester; Drs. John Remer and Wm. H. Stewart, New York City; Dr. P. M. Hickey, Detroit; Dr. G. C. Sutherland, Mayo Clinic, and Professor J. S. Shearer of Cornell University.

The various officers elect for the coming year are: President, Dr. G. E. Richards, Toronto; Vice Presidents: L. J. Carter, Brandon (First); W. A. Wilkins, Montreal (Second), and Dr. C. W. Prowd, Vancouver (Third). The Executive Committee is composed of the retiring President, Dr. A. H. Pirie, Montreal (Chairman); Dr. L. T. Pariseau, Montreal, and Dr. L. K. Poyntz, Victoria, with Dr. Poyntz also re-elected Secretary-Treasurer.

One of the features of the meeting was the decision of the Society to provide some method of recognizing qualified ethical lay technicians, the details to be worked out by the Executive Committee, but it was suggested that they should be required to pass an examination and be given annual registration. When the detailed plan has been completed we shall be pleased to forward you a copy.

The members of the Society greatly appreciate the attendance at their meeting of some of the members of the American Roentgen Ray Society, and wish to give here a formal expression of their thanks, and to hope that the meetings in future will be honored by a larger representation from the A. R. R. S.

L. K. Poyntz
Secretary-Treasurer.

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10 Newton Place
Glasgow,
October 1, 1921.

To the Editor:

In the August number of your most excellent Journal, which I read regularly with much profit and pleasure, there appeared an interesting article by Drs. J. M. and C. L. Martin on "Roentgen Ray Treatment of Acne Vulgaris." There are certain points raised in the paper to which I should like to call attention.

First the writers "abandoned the use of the coil." While not expressly stating that an accurate technique "by which therapeutic results may be repeated over and over again" is impossible with the coil, it is clearly implied. Here I am afraid the authors have "tramped on my corns." I *like* the coil. I am satisfied that it is quite as good as the rotary transformer for treatment with rays of the hardness described, and I think it is superior to the transformer when hard rays are to be used. The coil will serve a Coolidge tube quite satisfactorily, and permit of results being exactly repeated, and for years my dosage has been measured by time. The time is occasionally checked by the pastille. The authors must not condemn the *coil* because of the vagaries of a *gas tube* or faulty *milliamperemeters*.

With regard to Hampson's, Holzknecht's and Sabouraud's meters for rays of medium hardness—those in question—I have found them all fairly accurate. They are not ideal,

but from the practical point of view they are reliable. I would not attempt a temporary epilation (ringworm) without using one of them. The authors use the "physiological dose" method as elaborated by Wintz of Erlangen. Wintz, however, had to deal with rays of an entirely different quality, having a hardness corresponding to a 16 inch equivalent spark more than threee times the length, and filtered through a screen more than twenty times the density of that here used. These pastille tests are not intended for rays of that quality.

The second point I would like to raise, is the actual dose prescribed. In the conditions given five minutes "will produce a mild degree of reaction." The phrase, I suppose. will be generally understood to mean a dose equal to $5\ H$ or Sabouraud's tint B. This may not be the author's meaning, but I think I am right in assuming that it will be so understood in general.

Taking then their smallest dose—viz., three minutes, in a *fortnight* the patient will have received at least 9/5 or nearly twice the erythema dose, and he *might* have got three erythema doses. I would not repeat *one* erythema dose under a month; and in the above circumstances I would expect burns followed by late untoward results, such as telangiectasis.

Lastly, let me say that to the authors are due our thanks for calling attention to the fact that milliamperemeters require periodic checking, a fact very easily lost sight of.

James R. Riddle

To the Editor:

It gives us great pleasure to receive the above letter which comes from a distant land in a spirit of friendly censure. We have expected similar criticism from the roentgenologists of our own country, since we realize that our technique is more radical than that now generally accepted.

As to the use of the coil, the writer admits that nothing definitely derogatory was said in our article concerning this piece of apparatus. The senior member of our firm operated four coils with gas tubes for many years with satisfactory results. We did imply, however, that the rays from the gas tube energized by a coil was a variable quantity, and it was for this reason that the American roentgenologists have, for the most part, changed over to the Coolidge tube energized by the transformer. Since the modern transformer with its rectifying switch sends a pulsating direct current through the tube and since it does away with the variations so likely to occur in the interrupter and in the resistance coil control, we feel that it is preferable for therapeutic work, especially when equipped with a current stabilizer.

As to measuring devices, it is our feeling that there is no measuring apparatus quite so accurate as the human skin, and even that structure is subject to variations within limits. Our dose calculations are based on the work of Witherbee and Remer, rather than on that of Wintz of Erlangen. We would like to call attention to the fact that the work of these experimenters was done with the American-made transformer and a Coolidge tube and that the voltage and filters used were those noted in our article. The unit used in this work is called a skin unit, which represents a dose just large enough to produce alopecia. Acording to the formulae worked out for ½ mm. of aluminum filter

$$\frac{\text{MA} \times \text{Sp. gap} \times \text{time}}{\text{Dist.}} = \frac{99}{20} = 1 \text{ skin unit}$$

If our factors are substituted here, the time needed for one skin unit is, in round numbers, two minutes. Now, according to the observations of Witherbee and Remer published in the October, 1920, issue of The American Journal of Roentgenology, doubling the time with the filtration and factors that we use increases the dose by ¼. Therefore, with a four minute exposure, we would obtain 1-¼ skin units, which produces a mild erythema as illustrated by a photograph in the article just mentioned. A five minute exposure represents 1-⅜ skin units and some advanced cases of acne vulgaris do not show an erythema even after the use of this dose. A heavy piece of sole leather is placed beneath the ½ mm. of aluminum, and this probably reduces the skin effect by a small amount.

The advisability of repeating the doses mentioned in one week is also questioned. According to the work of Kingery published in the *Archives of Dermatology and Syph-*

ilis (1920), the residual effect at the end of seven days is about 20 per cent or 1/5 of the original dose. Now if 1-¼ skin units be added at this time the total amounts to about 1-9/20 skin units, which produces a definite erythema, but no vesiculation in the average skin.

Another factor that should be mentioned, is the size of the port of entry. Our work has been done with cones of moderate size. Larger doses can be given through small cones than through large ones in producing the same skin effect.

Summing up, we merely attempt to produce a mild erythema, which later gives place to a moderate tan and finally disappears. We feel that various skins require a rather wide variety of doses to produce this effect. The immediate results of this treatment seem superior to those obtained with long-continued fractional doses. One case of acne given an erythema dose just short of vesiculation twelve years ago, showed no untoward skin reaction when last seen one year ago. In examining our cases of skin malignancy which have been cured for five, six or seven years, we usually find the skin at the site of the lesions smooth and soft, though sometimes atrophic. Occasionally, telangiectases are observed. These patients received three or more skin units several years ago and rather marked reactions appeared at the time of treatment. The erythema produced in treating acne is of a much less degree than that produced in these cases. The reactions which appear as a result of the treatment are readily taken care of by the application of a mixture commonly called whitewash in this country. The formula for this mixture was obtained from the Massachusetts General Hospital and is given below:

Oxide of zinc	dr. iv
Glycerine	dr. ii
Phenol	dr. i
Aq. Calcis. qs. add	oz. vi

This wash seems to reduce the reaction to a minimum. We are not entirely convinced that serious later effects will follow the erythema dose when given in this manner.

J. M. and C. L. Martin

A CORRECTION

The paper entitled "Developmental Rests in the Cecum and Ascending Colon and their Roentgen Ray Diagnosis," by Dr. R. A. Payne and Mr. F. C. Trahar, published in the November Journal, was read at the joint meeting of the Pacific Coast and the Western Section of the American Roentgen Ray Society, and not as stated.

BOOK REVIEWS

DIE ROENTGENDIAGNOSTIK DER INNEREN KRANKHEITEN. By Herbert Assmann, M.D. Pages 693; 613 illustrations in the text and 20 tables. F. C. W. Vogel, Leipzig, 1921.

Conservatism runs through all the pages of Assman's book. This perhaps is due not only to racial objective habits of thought, but also to the author's particular medical environment. Under the dominance of Strümpell at the Leipzig Medical Clinic, roentgen diagnosis is not regarded as an independent specialty, but as one of many clinical methods, all of which must be taken together to solve diagnostic problems. Accordingly the author's experiences here presented have been constantly compared and associated with all other processes of examination. Emphasis is laid upon the value of operative and necroptic control. We would have his proofs beyond cavil. "For," as he states in the preface, "I am of the opinion that by premature conclusions from or overvaluation of roentgen signs the method will only be prejudiced. I regard it as extraordinarily important that the roentgen examiner shall understand not only the possibilities of the method but also its limitations." Yet the author is not totally lacking in enthusiasm; it is merely restrained by his abiding regard for the truth. His interest is keen, his faith in the proven facts of roentgenology is confident, and this book of nearly 700 pages attests his respect for the *x*-ray.

The table of contents includes the circulatory system, mediastinum, respiratory organs, digestive tract, abdominal organs, urinary system, nervous system, bones and joints, muscles, tendons, subcutaneous tissues.

To the heart and blood-vessels 133 pages are devoted. Methods of orthodiagraphy are fully set forth, together with tabulated standards, and the roentgen appearance of the circulatory apparatus both in health and disease are discussed *in extenso*.

His presentation of the more common respiratory diseases is admirably simple and clear. It is of interest to note that he takes issue with Rieder and Stürtz, who have many disciples, in their belief that pulmonary tuberculosis in adults commonly proceeds from the hilus toward the periphery retrogradely along the lymph channels, and that exaggeration of the upper lung markings is an important sign of early tuberculosis. Assmann holds rather with the school which attributes greater diagnostic value to mottling than to striations.

Regarding the diagnosis of pulmonary tuberculosis in general he says: "The great necessity is a knowledge of the underlying pathology. For accurate diagnosis great experience is required, not alone from many roentgenological examinations, but also by constant comparison with the clinical, and especially the necroptic, findings. This requirement cannot be emphasized sharply enough in view of the alacrity with which the roentgen diagnosis, for example, of 'tuberculous hilar glands' and 'peribronchial strands' is made in inexperienced quarters in cases that are not normal or at least not tuberculous. Illustrations have been published, stated to be characteristic for tuberculosis, in which, despite the most thorough examination, I could not discover the slightest changes."

Pulmonary tumors are dealt with rather briefly, and a wider review of the literature would have enhanced the value of this chapter.

The roentgenology of the gastrointestinal tract is covered quite thoroughly with 247 pages of text and illustration. As is usual with continental writers, indirect signs of disease are given prominence, but in some sections, notably that on duodenal ulcer, Assmann stresses the direct signs in almost the American manner, and gives due credit to Cole.

The chapter on the roentgenological signs of disease of the nervous system is limited in the main, of course, to the trophic changes observed in the osseous system. Various pathological conditions of the bones and joints proper are described succinctly, but with some beautiful roentgenograms. His discussion of the urinary system is disappointingly brief.

A striking feature of the book is the excellence of the paper and the clarity of the illustrations. Coming as it does from a land that is surely less prosperous than our own, the typographical qualities of the book might well be brought to the attention of American publishers.

R. D. CARMAN

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Paul B. Hoeber, 67-69 East 59th Street, New York